COMPARISONS

OF

STRUCTURE IN ANIMALS.

THE HAND AND THE ARM.

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COMPARISONS OF STRUCTURE IN ANIMALS.

CHAPTER I.

PRELIMINARY OBSERVATIONS.

The intelligent reader need not be apprised that the field of Comparative Anatomy is vast and extensive. So rich is the profusion of objects which it offers for contemplation, that the most powerful minds, after years of toilsome investigation and research, leave the greater part still unexplored; and though student succeeds student, and labourer follows labourer, the philosopher of a distant period, as he recognises the hand of God, will find occasion to say, with one of old, "Lo, these are parts of His ways: but how little a portion is heard of him!" Our sketch of some of the parts of animal structure will be

but slight : our aim is to touch upon points more especially interesting to the general reader ; while, at the same time, we shall endeavour to furnish some illustrations of the wisdom of that great, all-powerful God, who has condescended to reveal himself to fallen man, not only as the God of nature, but also as the God of providence and grace.

In the fulfilment of our plan, we shall endeavour to avoid the use of technical terms, even at the expense of precision of language; for, unless the reader be perfectly familiar with them, such terms tend to embarrass and perplex, perhaps even to deter him from pursuing a subject replete with instruction and well calculated to expand the intellect.

By way of introduction, it may be desirable to take a brief and general survey of the animal kingdom, in order that some idea may be entertained relative to its extent, and the vast multiplicity and diversity of beings which it comprehends—from man downwards to the microscopic animalcule.

For every conceivable mode of existence are animals created, and with parts, form, and organization adapted to their several exigencies. Setting man out of the question, highly exalted

as he is above the nearest of the brute creation, whose prospects are not bounded by the decay of his earthly body, the tenement of a spirit which never dies—some animals are much more elevated in the scale of being than others, and more sensitively enjoy existence, while death, not being anticipated, is but the pang of the moment. In these animals, a brain encased in a skull, and a spinal cord connected with the brain, and protected by a series of bones forming the vertebral column, are always present. Nevertheless, great is the difference between animals thus endowed; and widely do they vary in habits, manners, food, and instincts. Some are furnished with limbs, and have the body clothed with fur; they breathe the air, they traverse the ground, and range mountain and valley, plain and forest, desert and morass —we allude to quadrupeds; but of these, some, as the seals, are very aquatic in their habits—while others are completely so, as the blubber-clad whales, which, though not possessing four distinct limbs, belong to this class: they plough the great deep. There is, again, a class of air-breathing animals clad in feathers, and furnished with four limbs, of which the anterior pair are constructed as instruments of flight.

They rapidly traverse the air on wings, but they repose on the ground, in the trees, or on the surface of the water; hence birds are structurally modified for very diverse modes of life. Quadrupeds produce living young, but birds lay eggs, upon which the parent incubates, in order that the warmth communicated by her body may cause the development of the chick. Both quadrupeds and birds have warm red blood.

As we descend the scale, we come to groups in which the blood is cold, and the body is defended either with bony plates or shields, with a sort of tesselated horny armour, with scales, or is destitute of any covering. Some of these animals have four limbs, some two, some none. Many are aquatic in their habits, others terrestrial, and others arboreal. The greater number breathe air; some are constructed for both aquatic and atmospheric respiration. Some, during the first stages of their existence, are fitted for aquatic respiration exclusively; but, afterwards, from a strange alteration of structure, lose the power of aquatic respiration, and breathe only air. We allude to reptiles and amphibious creatures—to tortoises, crocodiles, lizards, snakes, sirens, and frogs; animals

which exhibit a wide range of structural variation, and habits and instincts of the most opposite character.

Last in the series of animals with a brain and spinal cord comes the vast variety of fishes. These animals are expressly constructed for the water in which they are destined to live, and through which many dart along with almost inconceivable velocity. They are furnished with gills for the purpose of aquatic respiration; their bodies are generally somewhat cylindrical, compressed at the sides, with a sharp pointed head, and an elongated muscular tail, terminated by a fin, which is the great instrument of locomotion, the fins of the body acting chiefly as rudders and balancers. However, there is great difference in the form of fishes, and, consequently, in the ease and celerity of their movements, and in their habits. Some have large heavy heads, as the cod-fish, and move leisurely—some are almost globular, as the tetraodon, which has a habit of floating on the surface of the water—some, again, as the skate, are depressed vertically, and are termed flat-fishes—some are compressed laterally, with the head twisted, or, as it were, distorted, so that both eyes are on the same side, such is the

sole—others, again, are elongated and somewhat snake-like, as the eel.

Most fishes are covered with scales, arranged in regular order; in some species, however, they are so minute, that, in a popular sense, the fish may be called naked, as, for example, the eel. In several species the skin is rough, being minutely granulated with hard tubercles. Some, as the pipe-fish and hippocampus, are invested with a sort of armour of indurated or horny plates; while in others, as the ostracion, these plates are so consolidated as to form a sort of bony box, the tail, the fins, and the mouth being alone movable.

It is not only by scales, or other appendages, that the skin of fishes is defended from the action of the water in which they dwell—they are externally lubricated by a tenacious slime· the secretion of certain glandular pores, whence it exudes abundantly. Most fishes produce eggs in vast numbers, collectively termed the *roe;* but some of the sharks are viviparous, and so is the angel-fish, (*Squatina angelus.*) This observation applies to reptiles, these animals being, as a rule, oviparous, with the exception of a few lizards, and certain venomous snakes, which produce living young.

It is to some interesting portions of structure presented by the animals of these four great groups or classes that we shall chiefly attend. They constitute, according to the arrangement of modern naturalists, a sub-kingdom of the animal world, termed by Cuvier the vertebrate; and in like manner the classes of animals still lower in the scale are grouped into great sub-kingdoms; but the grounds of distinction between those classes are, in many instances, less rigidly marked out. Their characters are, in fact, more indeterminate.

The sub-kingdom succeeding the vertebrate, (that is, possessing a true brain and spine,) comprehends numerous classes in which nerves exist, but in which there is no true brain, (in some, perhaps, rudiments of it,) but no spinal cord or spinal column. These have been commonly called molluscous animals, including the cuttlefishes, the nautilus, the little northern clio the food of the whale; slugs and snails, or univalve-shelled slugs, terrestrial and aquatic, as the whelk, the murex, etc.; bivalve-shells or shellfish, as oysters, mussels, etc.; certain mollusks invested in a sort of cartilaginous tunic, found in the warmer seas; including the pyrosoma, celebrated for its phosphorescence,

and others; to the barnacles, all arranged in their respective classes.

The next sub-kingdom, containing the crustaceous animals, as crabs and lobsters; the spiders and scorpions; true insects; the myriapods, millipedes, etc.; and the ringed worms, as the earthworm, leech, etc. In this sub-kingdom there are nerves uniting together a series of nervous knots termed ganglia, distributed with systematic regularity. The body consists of a succession of rings or annulations, formed by the integument, which may be soft, as in the leech, or rigid and calcareous, as in the lobster.

The next sub-kingdom comprehends the sea-urchins and star-fishes; the tripangs, so much esteemed in China as delicacies of the table; certain parasitic worms, as the guinea-worm, and the various species of ascaris; the wheel animalcules, and a group of curious zoophites, called moss corals, of which the flustra, common along our coasts, is an example. In this sub-kingdom the nerves, where traceable, appear in the form of minute threads diversely arranged.

The last sub-kingdom embraces the sea-anemones, the ordinary zoophites and coral-

forming polypes; the jelly-fish and sea-nettles; the polygastric animalcules; the sponges, and the tapeworms and hydatids. In this sub-kingdom, the body of the various animals it embraces consists of an apparently homogeneous gelatine, often investing a framework of solid material, often inclosed in tubes sometimes simple, sometimes beautifully frondescent; in other cases, it has no support: in some instances, the animals move freely at pleasure, in others they are fixed and have a plant-like existence. Some species are simple ; others form, by a vital union, a compound being, consisting of myriads of polypes, each distinct, yet all united into a whole by means of filaments, or a common gelatinous support. In some groups, we behold a number of bodies of a definite figure linked in floating chains together, but by a tie so slight that it is not easy to understand the nature of the union between them, or determine precisely whether this union be necessary for their individual vitality or not. In some groups a digestive laboratory is evident; in others mere canals traverse the gelatine through which the absorbed fluids circulate, till they are carried to a central cavity, and this is at once the apparatus of

nutrition and respiration. Many of these beings are beautifully phosphorescent; some exude an acrid humour, which gives pain to the hand incautiously applied to them. There is no distinction of sexes, and reproduction is either by the simple division of the original body into several parts, which ultimately assume the characteristic form, or by granules, which become gradually developed and detached from the parent; or by gemmules or buds, which, when thrown off, in due time display their specific characteristics.

But we must not extend these general observations by entering into particulars; suffice it, in the present place, to have alluded to them. Yet we have said enough to show the amazing extent of the animal kingdom, and the bewildering multiplicity, variety, and strangeness of the forms with which life is invested. Among the lowest groups of the animal creation, in particular, we are perpetually startled and ready to ask, Can these things truly belong to the animal kingdom? Can this plant-like assemblage of delicate stems and branches, studded with miniature cups and vases, or bell-like flowerets, and rooted upon a shell or pebble cast by the waves on the sea-beach—can this

be an animal? No, not itself an animal, but the tenement of myriads of polypes, united together by a gelatinous thread running through each tubular ramification; and as the shell is secreted and deposited by the snail, so is this rooted abode secreted by the living zoophite. "I can believe," some one may say, "that the beautiful sea-anemones which bestud the tide-covered rocks along our coast are animals, for I have watched the creatures expand their green and azure arms or feelers, encircle them round small crabs, and drag the victim to their mouth; but will you tell me that the sponge on my dressing-table is an animal?" It is not an animal, but it is the support of a gelatinous living film, which pervaded every pore of the elastic mass, and of which it may be considered as the rude skeleton. By that living gelatine, once a free swimming gemmule, the substance we call sponge, is secreted; that gemmule thrown out from one of the larger pores or canals of the parent sponge, swam about by means of little fibrils, till it found a suitable place on which to fix itself; there it adhered, and there, losing its pristine form, it became what it was when the diver or the dredger tore it from the rock, washed away the decomposing

gelatine, and sent the elastic mass into the commercial market. It is from the sponge and forms of a similar nature that the zoologist can ascend, by a series of gradations, more or less orderly, more or less intricate and irregular, up to the higher orders of the animal world; and it is worthy of notice, that, as a rule, the lowest forms of a higher order are truly lower in the scale of organization than the higher forms of a succeeding order. That worm-like fish, the myxine, (*Gastrobranchus cæcus*,) and another fish called the lancelet, (*Amphioxus lanceolatus*, Yarrell,) are less elaborately organized than the cunning, sharp-sighted, ferocious cuttlefish, the first of the molluscous series. But take some of the lower forms of this latter series—say the oyster or mussel—and compare them with the higher forms of the succeeding series, as the crab, lobster, scorpion, or beetle, and the superiority of these creatures is at once appreciated. So when we look at the worm of the same sub-kingdom we find it lower than the sea-urchins, star-fishes, etc. of the next sub-kingdom in rotation. And again, when we go to the lower forms of this sub-kingdom and compare them with any of the last sub-kingdom (*Acrita*,) we

find these excelled by the sea-anemones or actiniæ. Thus, then, the chain of being does not descend in a straight unbroken line, but by a series of lines, the one impinging upon the following below its commencement, or *vice versâ*, the last rising above where the preceding impinges, as in the annexed diagram.

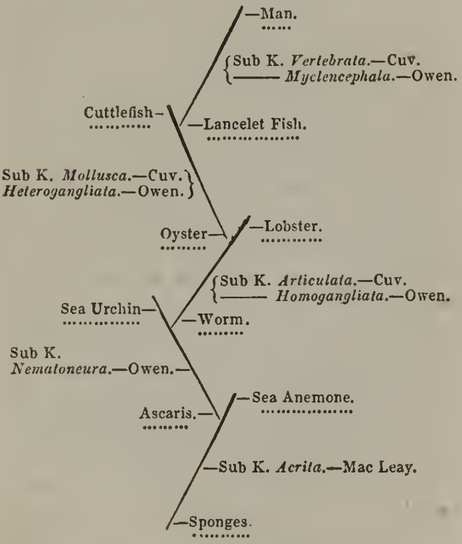


Diagram of the bearing, with respect to each other, of the great Sub-Kingdoms of the Animal Creation.

It is not only in form and structure, in the possession or absence of limbs, in the modifications of those limbs, in the possession or absence of a brain and spinal cord, in the possession or absence of the various organs of the senses, and in the adaptation of those organs for different conditions of being, that the animal creation offers such an apparently endless variation ; nor yet is it in size, though the range of magnitude is from the Greenland whale to the animalcule, of which thousands sport and play in a drop of water ; but also in the purposes, the final ends of existence, for which animals were created, that this boundless extent of variation obtains. In multitudes of instances, indeed, purposes to be answered by the existence of animals are beyond our finite comprehension, yet reason urges upon us the axiom that nothing is created in vain; and it is not because our imperfect minds cannot comprehend the whole of the mighty scheme of creation, that we are to doubt that even the minutest animalcule is created for some specific object, and has its appointed part in the great system. A doubt of the final causes of the existence of all living creatures, (plants included,) without exception,

and throughout all their changes, involves the question, as to why any were created. But life teems on the globe, and wherever it can be, there, animating some body, some form, it will be; and if we can conceive of a single purpose only, to be effected by the existence of one living thing, we are bound to acknowledge that it is because of our feeble comprehension we cannot trace it throughout organic creation. David of old, in meditation upon the works of God, exclaimed, "O Lord, how manifold are thy works! in wisdom hast thou made them all: the earth is full of thy riches. So is this great and wide sea, wherein are things creeping innumerable, both small and great beasts." And truly in the structure of every creature, and in its adaptation to a peculiar line of habits and manners, we discern clearly the wisdom and power of the Creator. This structure, varying in its modifications to meet certain exigencies, involves the doctrine of final causes; unless, indeed, we are to take the atheists' creed, and ascribe organic life to a fortuitous concurrence of atoms under incomprehensible conditions—a theory as weak and puerile as it is low, vile, and abominable. But it is thus that man too often attempts to veil

his ignorance, uttering words without wisdom, when to have acknowledged his incapacity would have been more genuine philosophy. We cannot, as we have observed, explain the final causes for the creation of the boundless diversity of organic existence, but we can perceive that a unity of design runs throughout every part; we can trace the marks and strokes, thus to speak, of the same Master's hand, to whatever portion of the vast whole we turn our attention; proofs of boundless inscrutable wisdom, knowledge, foresight and power, manifested in different designs and contrivances to answer definite ends, to meet a thousand contingencies; and we almost involuntarily repeat, "He that planted the ear, shall he not hear? he that formed the eye, shall he not see?" Such are the great truths of natural theology, which aims at a display of the perfections of God as declared by his works. But the Christian can appeal to other great truths, which demonstrate God's mercy towards the human race—he can adduce the gospel scheme of salvation, which declares the necessity of an atonement for sin, receive Christ by faith as that sacrifice of atonement, and thus glorify God not only as his Creator,

and the Maker of things visible and invisible, but as his Lawgiver, Judge, and Saviour. Impressed with the important truths revealed in his word, led by faith to the Redeemer, who gave his life a ransom for sinners, the Christian will receive with a higher tone of delight than the mere philosopher, the proofs of the Almighty's power, which a contemplation of his wisdom and skill in creation must call up, and rejoice to see imprinted upon every living thing the mystic writing of his all-powerful hand. He will find that nothing is superfluous; no organs are given, for which there is not an express use, no part of the organic structure is unimportant, no part independent of another, the result being a harmonious accordance of the whole; as nothing is superfluous, so nothing is defective; nothing fails for the accomplishment of the destined purpose; there is no misapplication of power; there are no errors in calculation, to use a term applicable only to human contrivances and machinery—every lever, every muscle, every blood-vessel, every nerve, every tissue is admirably arranged, and expressly adapted for the end in view. Nor is all this irrespective of beauty, delicacy, and precision. Everything

is beautiful in its construction, everything elaborately finished; whatever structure or tissue we examine by the aid of the microscope, we shall be surprised at the elaborate minuteness of its component fibres or particles, and their exquisite arrangement. The more we investigate, the more we shall wonder, admire, and praise. How inscrutable is the wisdom of the Creator! how forcibly do his works proclaim his power! Can the Christian, while he examines these wonderful proofs of design, wisdom, and power in creation, doubt his wisdom, design, and power in providence? Can we doubt that He who created the heaven and the earth, and who said, "Let there be light, and there was light," ruleth over the ways of his creatures—over the ways of man, whom he created in his own image, though that image is defaced by the entrance of sin into the world, bringing guilt and death? The very hairs of our head are numbered; and not a sparrow falls to the ground without his permission. Happy is the man who looks through nature up to the God of nature, providence, and grace, who has unfolded to us two revelations; one, of his might and majesty in the creation of suns, and moons, and stars,

of our globe, and all things upon it—the other, of his merciful designs in rescuing a fallen race from the fatal consequences of sin, through faith in the great Atonement, which breaks our fetters, and gives us the liberty of adopted children, and newness of life in the Redeemer.

Here we close our preliminary observations, and proceed to our main object—a sketch of some of the more interesting peculiarities in the structure of animal beings.

CHAPTER II.

ON THE ANTERIOR LIMBS OF QUADRUPEDS.

In proportion to the development of the brain and nervous system of animals will be that of their general organization. Consequently, as we ascend from the lower forms to the higher, we find a progressive refinement of structure, involving endless modifications, which evince the minutest attention to necessary details. Nor is this advance produced by adding, at every step, machinery to machinery, but by the happiest and easiest alteration, so to speak, of the machinery in common use, which we may admire, but cannot imitate. Let us, by way of example, trace the arm through some of its most remarkable characteristics, from that of man downwards.—The arm and the hand of man have been regarded with admiration from early antiquity, and may themselves be adduced in proof of man's position in creation.

The end of organization in animals is to provide instruments capable of duly administering to their instincts, intelligence, or necessities; and in this view of the subject, irrespective of everything else, we have data upon which to assert the immense superiority of man above all other animals. "It is not," says Galen, "because man has a hand, that he is, therefore, the wisest of creatures, as Anaxagoras asserted; it is because he is the wisest that therefore he has a hand, as Aristotle correctly thought. For it is not the hands themselves which have taught man the arts, but reason. The hands indeed are but the instruments of the arts, as the lyre is the instrument of the musician, the pincers of the worker in iron."

All the mammalia, excepting whales, porpoises, etc., have four limbs; and in all, man excepted, these limbs are organs of locomotion, though not in all cases of locomotion exclusively; for in some, either one or both pairs are constructed for grasping, and retaining—in many they serve as destructive weapons; and in others, as scrapers, or burrowing organs. We know that the monkey has the power of grasping both with the hands and feet, the lion and tiger strike down their prey and rend

it with their talons; the mole excavates galleries in the earth; but still in these and all other examples, even in the chimpanzee and orang, both pairs of limbs are locomotive organs.

On the contrary, the inferior extremities alone in man are organs of locomotion; his attitude is erect, his arms are free, and the arrangement of every portion of which they consist indicates their appointment as ministers of the will of an intellectual being. "Some animals," says Ray, "have horns, some have hoofs, some teeth, some talons, some claws, some spurs and beaks. Man hath none of all these, but is sent unarmed into the world, weak and feeble. Why? A hand, with reason to use it, supplies the use of all these." Without the arm and hand, indeed, man would not be able to carry out the designs to which the vigour of his intellectual powers prompts him. It is a law of creative providence, that every creature shall be adequately endowed for the accomplishment of its work according to the measure and direction of its instincts or intelligence. Nor is man excluded from this law; and as the head of the elephant would be preposterous on the neck of the giraffe, or the limbs of the antelope on the trunk of the lion, so would the

arm of man be useless to the lower animals, while that even of the orang would be inappropriate to man. The perfection of harmony runs through the organic structure of all creatures, and every being is in itself perfect. When, therefore, we say that man stands, in "form and moving," above all the lower creation—"the paragon of animals," we thereby imply that his organization bespeaks his towering intellectual supremacy, his moral nature, his great destiny; and that, therefore, physically, because he is so morally, he is the most excellent of creation, on our globe.

The arm and hand of man—and the same observation applies to the corresponding parts of all animals—constitute but one instrument every portion of which is requisite to the perfection of the whole; and when, in general terms, we speak of one, we include also the other part. Nevertheless the *arm* may be divided into the *hand*, the *fore-arm*, and the *upper-arm*, or *humerus*.

Let us look at the hand.—We see in it an instrument capable of grasping with vast energy and tenacity, or of compressing so gently as not to injure the delicate wing of the ephemera; it seizes the handle of the ponderous sledge-

hammer with a strenuous grip; it guides the pencil and the pen, or runs over the ivory keys of the piano with astonishing rapidity and precision. It accommodates its movements, its pressure, its force, its manipulation, to every exigency; it spins the thread from the distaff, and tests the delicacy of fabrics. It is not only an organ of prehension, it is the great organ of touch or tact; it ascertains the texture, the form, the smoothness, or hardness, the resistance, or compressibility of bodies subjected to its action; it, in fact, assists the eye in the task of ascertaining the qualities, and even the nearness or distance of objects presented to our senses. Nor is this all—it aids us in the expression of our feelings and passions. By the movements of the hands we invite, we repel, we command, we implore, we rejoice, we pardon, and even note the regularly recurring intervals of time; as in musical performances.

We shall not enter into the anatomical details of the hand, and to describe the form seems superfluous. We know that the four fingers, composed each of three joints, are of unequal length and strength, and are capable of being folded down more or less independ-

ently of each other, for no one finger indeed can be fairly doubled upon the palm by itself, though it is capable of partial inflexion. The stress of the fingers is directly towards the palm; but not so that of the thumb, which cannot, without some effort, be brought to press firmly against the palm, and even then it can only be applied in a lateral position. The structure of the thumb and the direction of motion allotted to it render it an antagonist to the fingers. It can firmly oppose its tip to the tip of each finger in succession, or to the whole of them at once; and when the fingers are folded upon the palm, or encircle any object, it can be brought to press upon them obliquely with great force, adding thereby very considerably to the energy of the grasp.

The fingers, as we have said, are of unequal length, and the advantages of this irregularity have often been made a subject of question. The advantages are more easily appreciated than explained. Nevertheless, if we consider the multitudinous and ever-varying manipulations which the fingers are called upon to execute, we shall soon see that their uniformity would be an imperfection. Indeed, unless they were graduated as they are, they would

continually interfere with each other, and their action would be clumsy and constrained; all the nicer and more delicate operations would be performed with awkwardness; and instead of assisting each other, they would impede each other in every rapid and skilful movement or application. When, however, the fingers are folded down upon the palm, the tips are brought nearly to a level, and also when made to grasp a ball. In grasping the hilt of a foil, they are likewise brought to a level, but their direction is oblique, resulting from the peculiar manner in which it is held; and in this mode other instruments, as the knife, the poker, and various articles, are handled. It is a mode in which firmness is conjoined with ease and address.

As an organ of touch, the perfection of the human hand is owing, in a great measure, to its admirable structure as an instrument of prehension. The sense of feeling is indeed diffused over every portion of the external surface of the body, which is capable of receiving impressions from contact, and changes of temperature; but the hand alone is strictly the organ of touch, and is peculiarly fitted for ascertaining the figure, consistency,

and general qualities of bodies. The whole of the palmar surface is exquisitely sensitive, but it is on the pulpy tips of the fingers that the greatest sensibility resides. There the multitudinous nerves form a congeries of papillæ, supported on cushions of cellular tissue, and protected by the nails. These latter add firmness to the tips of the fingers, and serve not only as a support, but also as a barrier between external bodies and the nerves beneath them, thereby intercepting the communication of definite impressions, in order that the nervous energy may be more fully concentrated on the pulpy portion appropriated to touch, and that the impressions there received may be the more definite and vivid. The nails arise out of the true skin, and grow from a pulpy root; they are closely attached to the soft parts, which they cover, and cannot be torn away without intense pain. From the arrangement of the muscles of the palm, which bend the thumb and fingers, the centre of the palm is concave, and by this provision the hand is more efficient under many circumstances as an instrument of prehension. To this, also, the roughness, or rigid linear markings of the cuticle of the palm and inside of the

fingers contributes, no less than to nicety of perception in testing the quality of the surface of objects, and which, had the cuticle been smoothly polished, would have been at a much lower ratio. To persons accustomed to heavy labour—as the blacksmith and ploughman—the cuticle becomes much thickened, and operates as a defence to the nervous tissue, though at the same time it interferes with delicacy of tact. "The hand of little labour has the nicer sense."

Such is a general sketch of the human hand considered restrictively; and conformable to it is the arm, according to that principle of harmony which ever prevails in organic bodies. The peculiar flexibility of the wrist joint, the power of flexure, and of pronation and supination enjoyed by the fore-arm, and the amazing freedom of the shoulder-joint, which permits the arms to be whirled about, are all essential to the efficacy of the hand, and the multitude of purposes to which it is applied. It is in a shallow socket of the blade-bone (*scapula*) that the shoulder-bone (*humerus*) moves freely; and the blades are kept in their position by two clavicles, or collar-bones, which extend between them and the top of the breast-bone. Thus are the shoulders kept

apart from the chest, and the arms, instead of being drawn to the latter by muscular exertion, thereby interfering with its due expansion, and their own freedom, are at full liberty.

Let us now turn to the analogous parts of the lower animals,—and first let us take the ape tribe, which are called quadrumanous, that is, four-handed, because all four extremities are constructed as graspers. In man alone, of all the mammalia, is the erect bipedous attitude easy and natural. The structure of the spine and trunk, the bony and muscular development of the lower limbs, and the balance of the skull on the top of the vertebral column, combine to necessitate such an attitude. In the ape tribe, animals for the most part of arboreal habits, their progression on the ground is on all fours, and their attitude is crouching, or more or less diagonal—a posture intermediate between the upright and horizontal. The lower part of the trunk is contracted and slender — there is no development of the haunch bones and their muscles—the thighs are meagre and ordinarily drawn up to the body, with the knees acutely bent, a position favourable for sudden and vigorous leaps, which these animals execute with great address.

In the chimpanzee and orang, however, there is, to a certain extent, a greater approximation to the human form and attitude; these animals can with some difficulty, and by the aid of their long arms balancing themselves, proceed for a short distance in an erect posture; but the gait is an unsteady hobble—they cannot walk with a firm step, nor run, nor leap, like man. If we rigorously scrutinize the hands of the ape tribe, we shall soon perceive that they are instruments for grasping, rather than organs structurally adapted for tact and nice manipulation. They are narrow and elongated; the palm is flat, and in many species—as, for example, the long-armed gibbons of the Indian islands—linear, expanding from the wrist to the base of the fingers. In all, the thumb is short and feeble; in none is it a fair antagonist to the fingers, though, in some species, it is better developed than in others. In the gibbons, the short thumb is divided down to the wrist, or nearly so, and is not opposable to the fingers; the ball formed by the adductor muscles is very trifling, but in the feet, or hinder graspers, the thumb is greatly developed, and forms an equal antagonist to the other toes conjointly—and,

indeed, as a general rule, the hinder graspers of these animals approach nearer to the human hand, as far as the development of the thumb is concerned, than do the fore-hands, or graspers. In some of the American monkeys, the thumb is wanting, or reduced to a mere rudiment beneath the skin, and in those which possess it, it is on the same plane with the fingers, or utterly unopposable to them, and bends like the fingers in the same direction. A true thumb, however, exists in the hinder graspers; and it is remarkable that among certain groups of the American monkeys, we meet with an accessory organ for grasping, namely, a strongly prehensile tail, by which they can suspend themselves head downwards from the branches. The prehensile tail of the spider-monkeys, of the opossums, and some other quadrupeds, may indeed be regarded as an accessory hand, or grasper, not only from the power of clinging tenaciously with which it is endowed, but also from the sense of touch which it possesses, apparently in as high a degree, or even perhaps higher, than the paws themselves. Indeed, the extremity of the tail, in the spider-monkey, is finger-like, and is capable of seizing small objects with great

address; and the animals are said to introduce it into the hollows and fissures of trees, in order to hook out eggs, which they relish as food. The naked portion of the prehensile tail of the Australian phalangers is also highly sensitive.

In all the ape and monkey tribes, the arms are proportionally longer than in man: but there is considerable difference among them. In the orang and gibbons, the arms are so long that when the animals stand in an erect position they nearly touch the ground; the hands too are of extreme length, while the hinder limbs are greatly abbreviated; but, in the baboons, which are far more terrestrial in their habits, and never attempt to assume an erect posture, there is more equality between the anterior and posterior limbs. In many, the fore-arm greatly exceeds the upper-arm, or humerus, in length, and of the two bones of the fore-arm that called the radius, on which the pronation and supination of the hand depend, is the stoutest, a condition the reverse of that which we find in the human skeleton. As a rule the blade-bones are far more lateral than in man, and the clavicles or collar-bones are shorter and straighter. Such, then, are

the rude hands or graspers of the ape tribe; they are not destined for "the purposes of ingenuity and art;" they are not organs corresponding to a highly developed intellect; they are not the servants of mind, but are rather "adaptations of the feet to the branches on which the animals climb and walk." Nevertheless the arm and hand of these creatures approximate nearer to those of the human subject than is found in any other quadruped. It has been observed as a rule, "that all animals which freely use the fore-paws, either for holding, digging, climbing, or flying, and which have the fore-arm in a greater or less degree capable of revolving, possess a clavicle more or less developed." In some animals that dig, as the mole, it is of great thickness and strength, while in the cat tribe it is a mere rudiment imbedded in the muscles of the shoulder. In the bat it is well formed. The bat is expressly organized for flight; the bones of the arms, and also of the fingers of the hands, are greatly elongated, and, like the strips of whalebone in an umbrella, serve as stretchers to an extensive and very delicate membrane, which can be folded up or unfolded at pleasure. The sensibility of these

membranous wings is extreme; they are capable of appreciating the vibrations of the atmosphere, its currents, its quiescence, and its more subtile conditions, with such refined nicety, that if the animal's eyes be covered up, it will direct its course, avoiding every obstacle in its way with the most surprising address. The thumb of the bat is short and free, and armed, as are the hind toes, with a hooked claw, enabling the creature to climb and shuffle itself along.

How different the structure of these membranous organs of flight from the stout, short, spade-like paws of the burrowing mole; and how wisely has Providence assigned to each creature that modification of structure which is in due accordance with its instincts! The very form of the mole shows it to be a burrower; it lives, it rears its young, and pursues its prey under ground, only occasionally visiting the surface; it works out its mines and galleries with marvellous ease and celerity, extending them in various directions in quest of worms, which constitute its principal food. If we look at its fore-paws we are at once struck with their strength, breadth, and solidity; the fingers are short and thick, com-

pacted together, and armed with nails of great size, which are concave below and pointed at the tip; in their ordinary position the palms are turned obliquely outwards, so that in the act of scraping, the earth is thrown on each side of the animal. With these efficient instruments the bones and muscles of the arm and chest are in complete accordance: the bones of the arms are short, but very thick and solid, and the clavicles are almost in the form of a solid square. The power concentrated in the anterior limbs of this animal is indeed enormous, and in this respect it perhaps excels every other burrower, even the armadillo and the chlamyphorus. In such instruments we do not look for much sensibility, or the power of manipulation; the paws are scrapers or shovels, and their use forbids that they should be more.

From the burrowing mole let us turn to the arboreal sloth—arboreal, but in a dissimilar manner from the monkey. The sloth lives not upon, but suspended under, the branches, and travels along them in the dense forests of South America, with the back downwards. It lives a life of clinging; and to this end its limbs are structurally adapted. The arms are very long,

and the clavicles are doubly united to the blade-bones. The hand is a hook, (trebled in some species, doubled in another,) by means of which the animal suspends itself. The bones of the wrist are consolidated into a single piece, and the three (or two) fingers are short and arched inwards, the joints of the bones being adjusted upon a principle of unyielding strength. These fingers are furnished with enormous curved claws, or hooks, alone projecting from the undivided skin, which enshrouds together all the rest, both fingers and wrist. Hence, on looking at the clingers of the sloth, it would seem as if these claws alone constituted the digital portion. They can only move altogether ; and, in their ordinary state, they are drawn forcibly towards the palm by the action of elastic ligaments, and require the voluntary exertion of the extensor muscles to unclose them ; and this being discontinued, the elastic springs again draw them to the palm. In clinging, therefore, whether during repose or while travelling along, the sloth has not to trust alone to the exertion of voluntary muscles for its safety. The ligaments, ever in operation, are sufficiently tense to counteract the tendency of the body's weight to relax them. The long and

intensely powerful arms of the sloth enjoy great freedom of movement. The animal, while resting, can stretch them out in every direction, in order to collect the tender buds and leaves on which it feeds, or draw down the young twigs to its mouth. These arms, thus provided with powerful claws, are formidable instruments of defence. Serpents capable of ascending trees, are among the sloth's most dreaded enemies; but these it can grapple and crush, as with the power of a vice, by means of its terrible claws. When attacked on the ground, to which it very seldom voluntarily descends, it throws itself on its back, strikes vigorously with its paws, endeavouring to grapple with its antagonist; and has been known to strangle a dog, holding him at arms' length. The long continuance and the unyielding rigidity of the grasp of the sloth, are very remarkable, betokening an almost spasmodic contraction of the muscles, and are, doubtless, connected with a peculiar plexiform arrangement of the arteries of the limbs. On one occasion, as related by Kircher, a long pole was put under the feet of one of these animals, which it seized very firmly, and would not let go again. The animal thus voluntarily sus-

pended was placed between two beams along with the pole, and there it remained, without meat, drink, or sleep, forty days. At last, on being taken down, a dog was most cruelly let loose upon it. The sloth grappled with him, and held him for four days, till he died of hunger.

Organized expressly in every part of its structure for its peculiar mode of life, we shall not be surprised at the awkwardness of the sloth on the ground. There it can neither stand nor walk, but lies sprawling, and drags itself along by laying hold of whatever it can apply its grappling-hooks to, as a stone, or a tuft of grass, and so makes a tedious progress.

So singular, so anomalous, is the general structure of the sloth, that it has been deemed by some a sort of failure, a piece of imperfection, in strong contrast with the beauty and propriety of organization exhibited by other animals. How it is possible that so great a philosopher as Cuvier could have entertained any such idea is surprising. It verifies the old adage, "*Nonnunquam dormitat Homerus*," sometimes Homer sleeps—the greatest of men are not always equal to themselves. So far is the sloth from being a piece of imperfection in

the animal creation, that we may rather appeal to it as a proof of most exquisite design and forethought. It is as elaborately formed for its appointed mode of life as is the active chamois for the rocks, the antelope for the desert, the mole for its burrow, or the whale for the waters of the ocean; and as much as they does it enjoy its existence.

While speaking of the sloth, we may allude to two huge animals, in many respects related to it, though not arboreal in their habits—we mean those extinct animals, the megatherium and the mylodon, the fossil bones of which occur in superficial strata in South America. A nearly perfect skeleton of the latter adorns the noble museum of the Royal College of Surgeons, London. On the structure of these animals, a profoundly philosophic work has been written by professor Owen. From this able zoologist we learn that a physiological review of the skeleton of the mylodon leads to the conclusion, that, as the teeth and jaws were expressly adapted for the comminution of foliage, so the trunk and extremities derived from their apparently ill-assorted proportions the requisite power of obtaining food by the uprooting of trees. We shall not enter

into the minutiæ of osteological details, but merely observe, that, in comparison with the massive bones of the limbs of these animals, those of the elephant are slender and puny. The claws, as the size of the terminal joint of the toes and its characters indicate, must have been enormous; and, as is proved by the volume of the haunch-bone, the strength and thickness of the short tail, and the form of the bones of the hinder limbs, that the animals could rest supported on them as on a tripod, while they applied their enormous powers to the trunk of the tree destined to be laid prostrate. Thus did these terrestrial sloths of giant bulk obtain their leafy food. With slow and heavy pace, treading on the outer side of the foot, (of which the external toes were encased in hoofs, the others furnished with tremendous claws,) did the mylodon traverse the forest, much after the manner of the great ant-eater, the claws doubled against the palm; but instead of seeking for the mounds of the termite-ants, which the latter animal tears open with astonishing force, it roamed in search of some tree, capable, perhaps, for several days, of affording it an abundant supply. After a rigid analysis of the framework of these gigantic

extinct sloths, professor Owen thus expresses himself :—"If the foregoing physiological interpretation of the osseous framework of the gigantic extinct sloths be the true one, they may be supposed to have commenced the process of prostrating the chosen tree by scratching away the soil from the roots ; for which office we find in the mylodon, the modern scansorial (climbing) fore-foot of the sloth modified after the type of that of the partially fossorial (digging) ant-eater. The compressed or subcompressed form of the claws, which detracts from their power as burrowing instruments, adds to their fitness for penetrating the interspaces of roots, and for exposing and liberating them from the attached soil. This operation having been duly effected by the alternate action of the fore-feet, aided, probably, by the unguiculate (clawed) digits of the hind feet, the long and curved fore-claws which are habitually flexed (bent) and fettered in the movements of extension, would next be applied to the opposite sides of the loosened trunk of the tree. And now the mylodon would derive the full advantage of those modifications of its fore-feet, by which it resembles the sloth ; the correspondence in the structure of the prehen-

sile instruments of the existing and extinct sloths, extending as far as was compatible with the different degrees of resistance to be overcome. In the small climbing sloth, the claws are long and slender, having only to bear the weight of the animal's light body, which is approximated by the action of the muscles towards the grasped branch as to a fixed point. The stouter proportions of the prehensile hooks of the mylodon accord with the harder task of overcoming the resistance of the object seized, and bringing it down to the body. For the long slender brachial (upper-arm) and antibrachial (fore-arm) bones of the climbing sloth, we find substituted in its gigantic predecessor a humerus, radius, and ulna, of more robust proportions—of such proportions, indeed, in the *mylodon robustus*, as are unknown in any other existing or extinct animal.

"The tree being thus partially undermined and firmly grappled with, the muscles of the trunk, the pelvis, and hind limbs, animated by the nervous influence of the unusually large spinal cord, would combine their forces with those of the anterior members in the efforts at prostration. And now let us picture to ourselves the massive frame of the megatherium

(which far exceeded the mylodon in size,) convulsed with the mighty wrestling, every vibrating fibre reacting upon its bony attachment with a force which the sharp and strong crests and apophyses (of the bones) loudly bespeak; extraordinary must have been the strength and proportions of that tree, which, rocked to and fro, right and left, in such an embrace, could long withstand the efforts of its ponderous assailant."

From this review of the arboreal sloth of the present day and its extinct colossal relatives, the wrestlers with the trees, we may pass on to the consideration of another remarkable modification in the hand and arm, tending to the production of a terrible weapon of destruction. We allude to the structure of these portions of the frame in the feline group.

Who that has contemplated the paw and arm of the lion, has not been struck with the exhibition of power which it displays? Bones dense and solid; voluminous and strongly-marked muscles; and formidable claws, conjoined with considerable freedom of movement in every part of the limb, are sufficient evidences of the fatal purposes to which it is applied; but when we come to examine the structural

peculiarities more narrowly, we shall find that they appeal to us, in the strongest manner, as proofs of consummate design. The lion—and our observation applies to the feline tribe generally—is, for the most part, nocturnal in its habits. These animals are endowed with the sense of sight in exquisite perfection, and it is by this sense rather than by that of smell, that they follow their prey, crouching and stealthily moving towards it with noiseless steps, till it is within the range of their sudden bound. All their movements are easy, light, vigorous, and free; their patience is very great, and they will watch in ambush for their victim for hours together; and with instantaneous quickness they seize the proper moment of assault. Let us see how the structure of the fore-limbs harmonizes with these habits. Let us look at the lion's paw. How heavy, how sinewy, how solid, and how strongly-knit every joint! How efficient as a weapon of laceration! Observe the pads or cushions on its under surface and the power of protruding and retracting the claws. Heavy as the lion is, yet he treads with a silent foot-fall; his foot is padded on the sole or palm, with a large elastic cushion of fatty cellular tissue, upwards of two inches in thick-

ness, and a similar but smaller cushion is placed under each toe. The use of these pads is very great. Not only do they render the tread of the animal noiseless, but they conjoin also with the elasticity of the limbs, or rather of the wrist, and the other joints, where the bones form acute angles with each other, to break the concussion which the shoulder and spine would be liable to receive from the violence of the animal's plunge in bounding, and especially where the aim was missed, for into this plunge the whole of the muscular energy of the frame is poured. Still more manifest is another use of these pads, especially those of the toes; by their position they raise the tips of the toes from the ground, and thus elevate the sheathed talons, so as to prevent the possibility of the points being worn blunt or ragged, for the talons, though sheathed, have just their points exposed, but buried by the fur. These pads unite also with the arrangement of the bones of the limbs, and the modification of the spine, in giving a certain ease and elasticity of tread, peculiarly observable when these animals pursue their way by a succession of graceful bounds. With respect to the extrusion of the talons and their retraction, the mechanism

by which these alternate movements is accomplished is very beautiful yet very simple. The claw or talon, we may observe, encases the last or terminal phalangal bone of the toe; now this bone is placed lateral to the one preceding, and is articulated to it by a rolling hinge-like joint; when the talon is drawn back, it passes down the outer side of the preceding bone, which side is flattened off, so as to offer no impediment. Thus the claw may be rolled back into a sheath of skin, and again rolled forward and unsheathed when required for use. In the latter case, the action is voluntary, in the former, involuntary; for the rolling back into the sheath is effected by the agency of an elastic spring-ligament which passes from the upper arch of the talon-bone obliquely down to the next bone, where it is firmly secured near the joint. In rolling forward the talon-bone, this ligament is strained on the stretch, and ready to act, the moment the muscular power which brought the talon forward ceases. We see, then, that it is by the contraction of the powerful flexor muscles, voluntarily exerted, and which are connected, by means of a very strong tendon, with the base of the talon-bone at its anterior part, that the formidable claw is unsheathed; and when

these retractor muscles relax, the spring-ligament, contracting, rolls back the claw into its sheath alongside of the preceding bone. When the lion, tiger, or cat, spring upon their prey and clutch it in their paws or strike it violently, the powerful flexor muscles are put into energetic action and forcibly unsheath the claw, these muscles and the spring-ligaments being alternate in their agency. Every one has not the opportunity of examining the paw of the lion or tiger, but every one may examine that of the domestic cat, which will exemplify the description we have given.

In the dog tribe, which, though carnivorous, do not strike or tear their prey with the claws, but seize it with the mouth, the claws are not retractile, and are comparatively feeble, short, and blunt: in the weasel tribe, however, which climb trees, and seize upon birds and small animals, the claws are sharp and retractile.

Among the rodent (gnawing) animals, there is great diversity in the form of the paws, and freedom of the fore-limbs, in accordance with the diversity of their habits: the squirrel has great liberty, and can climb trees with the utmost address; the toes are armed with

sharp claws. In others, as in the Cape leaping-hare, the fore-paws, armed with stout claws, are expressly adapted for burrowing. In the aquatic copybara of South America, the toes are furnished with small claws, closely resembling little hoofs. Generally speaking, in the rodent order, the fore-arm enjoys, to a considerable extent, the power of pronation and supination,* that is, of being turned partially round at the elbow-joint, though in the porcupine and the agouti this power is very much restricted. Most possess clavicles, more or less perfectly developed, and many hold their food between their two fore-paws, while they sit on their haunches and nibble it ; they also use the paws in cleaning and dressing their fur.

We must now pass on to the consideration of limbs modelled upon a plan differing materially from any that we have hitherto explained—limbs the structure of which is utterly incompatible with the presence of a collar-bone, with any degree of rotation at the shoulder-joint, the slightest power of pronation

* If the fore-arm be placed on a table, flat, and with the palm uppermost, the fore-arm is in a state of supination; but if it be turned round, so as to make the back of the hand uppermost, it is in a state of pronation.

or supination at the elbow joint, or with any laxity at the joint analogous to the wrist.

Such are the limbs of the elephant, hog, camel, deer, antelope, and horse.

The elephant, heavy and clumsy, yet gifted with a proboscis which it uses as an instrument of prehension and an organ of touch, displays in its gait an utter want of that spring and elasticity so conspicuous in many other animals. Nor is it difficult to account for this, when we come to examine the limbs: in the first place, the bones all bear perpendicularly, or nearly so, on each other, without making acute angles at the joints. Unite end to end several sticks by means of springs of steel, arranging the spring-joints in two or three angles or zigzags, then press one end on the ground, and you will see with what freedom the whole will play; it represents a limb, with the bones, muscles, and ligaments. Straighten the pieces of wood, bringing them into a line, press the end to the ground, and though the spring-joints may bend, the whole does not show the play of the former; it will not be "tremulous on wires." Such is the way in which the solid bones of the limbs of the elephant bear on each other; from the blade bone to the foot the line is straight, and conse-

quently there is no spring—no yielding and rebound.

The bones of the fore limb in the elephant consist of the broad scapula or blade-bone, the upper-arm bone or humerus, which bears perpendicularly upon the two bones (*radius* and *ulna*) of the fore-arm. To these succeed the wrist or carpal bones, well knit together; and next follow a row of short, stout, meta-carpal bones, five in number, succeeded by the phalangal bones of the toes. When clothed with muscles and dense, coarse skin, no part of the toes, except the hoofed tips, are visible; the whole leg and foot resembles the rugged trunk of a tree, formed into a rude pillar. On the same principle exactly, are the hinder limbs modelled. In the huge extinct mastodon, of which a noble skeleton adorns the British Museum, the general structure of the limbs resembles what we see in the elephant. Little less clumsy are the limbs of the rhinoceros, hippopotamus, and tapir. The carpus or wrist consists of short, thick, solid bones; the meta-carpal bones, however, are longer than in the elephant, and the toes (four in the tapir and hippopotamus) are somewhat more apparent, in the living animals. In the hog, the meta-carpal bones are still longer, they are four in

number, answering to the number of the toes, all furnished with a hoof, casing the last bone; it is, however, on the two middle toes only that the hog rests, the two lateral being short and feeble, though perfect.

From the limbs of these heavy, clumsy animals, and particularly those of the elephant, let us turn to those of the horse, the contrast between them being very striking. Here we find the bones of the shoulder, namely, the blade-bone and humerus, forming an oblique angle with each other, the former receding from the shoulder-joint, and directed towards the long, spinous processes of the vertebræ at the back at the withers. From the shoulder-joint the humerus retreats, forming an angle at the elbow-joint. In the fore-arm, the two bones (*ulna* and *radius*) are consolidated into one. The wrist-bones (*carpus*) form what is commonly and conveniently termed the knee; and below these well-knit bones, is a single long bone called the canon-bone; it represents the metacarpal bones (bones on which the fingers and paws are based) in other animals.*

* There are two lesser bones on each side of the canon-bone, posteriorly, which enter into the structure of the knee; they are called splint bones, and may be regarded as rudimentary vestiges of two metacarpal bones.

Then comes the elastic pastern, and the coffin-bone, representing the three joints of the fingers or toes. The pastern-bones are, first, the true pastern-bone, secondly, the coronal or crown-bone. The coffin-bone is inclosed in the hoof, at the bottom of which is the elastic, triangular, semi-cartilaginous cushion, called the frog, covered with a layer of horn. In like manner, are the hind limbs modified. The result of the angular bearing of the bones of the shoulder relative to each other, of the elasticity of the pastern and of the frog, is ease, vigour, and lightness of movement. The shock which the shoulder and body would receive as the animal trots, gallops, or leaps, is broken, each joint yields, and like a spring recovers itself. Moreover, the blade-bone is not united to the rest of the skeleton by any collar-bone, so that besides the joints the whole limb itself yields and recovers, the great muscle attached to the blade-bone, (called the *serratus magnus*,) and upon which the weight of the body anteriorly hangs, relaxing and then contracting its fibres. "Were the anterior extremities," says sir C. Bell, "joined to the trunk firmly and by bone, they could not withstand the shock from the descent of the

whole weight thrown forwards; even though they were as powerful as the posterior extremities, they would suffer fracture or dislocation. We cannot but admire, therefore, the provision in all quadrupeds whose speed is great, and whose spring is extensive, that from the structure of their bones, they have an elastic resistance by which the shock of descending is diminished." And again: "Were the bones of the fore limbs connected together in a straight line end to end, the shock of alighting would be conveyed through a solid column, and the bones of the foot or the joints would suffer from the concussion. When the rider is thrown forward on his hands, and more certainly when he is pitched on his shoulder, the collar-bone is broken, because in man this bone forms a link of connexion between the shoulder and the trunk, so as to receive the whole shock; and the same would happen in the horse, the stag, and all quadrupeds of great strength and swiftness, were not the scapulæ sustained by muscles and not by bones, and did not the bones recoil and fold up." How wisely, then, has the Almighty provided for the creatures of his hand! What forethought, what care, what judgment, to speak

after the manner of men, has he not displayed in the structure of organic beings!

In the ruminating quadrupeds—as the ox, deer, antelope, and others—the hoofed foot is *bifid;* that is, two toes are attached to the canon-bone ;* and besides these, there are two small lateral rudimentary toes, as in the ox.

The hoofs of ruminants are modified according to the locality the species are respectively destined to occupy ; but there are two animals belonging to this tribe, the structure of whose feet claims notice—we allude to the camel and the llama.

The camel, aptly termed the ship of the desert, is destined for the burning sands of a wide-spread waste, and still occupies as of yore its ancient home. Still, with slow and silent march, does the caravan of camels wend its way over the Syrian and Arabian deserts, as it did in the time of Joseph, when "a company of Ishmeelites came from Gilead, with their camels bearing spicery and balm and myrrh, going to carry it down to Egypt."

The camel does not tread on the hoofed points of its toes like the ox or antelope, but

* There is no canon-bone in the hog, but four true and proportionate metacarpal bones.

much more flatly ; their tips only are encased in small hoofs ; and on their under surface they are cushioned with a large elastic pad, connecting them together, and spreading out on each side. This pad expands by pressure at each step ; and by this provision the animal, while traversing the sands, is prevented from sinking over the feet, which would cause additional labour ; while on a rocky ground, or over stony passes, the elasticity of the callous pad gives ease to its movements. The limbs are meagre, and appear to yield at every step ; but they are in reality endowed with immense strength and power of endurance. The ordinary load of a good camel is five or six hundred pounds ; and with this weight, the animal moves at the rate of nearly three miles an hour, regular as clockwork, for eight hours a day, during a period of many successive days or even weeks.

The llama may be regarded as the camel of the Andes, and was once the only beast of burden among the Peruvians. The sterile craggy rocks and mountain valleys are its home, and its feet are modified accordingly. They are formed for security on a rugged surface. We see two springy toes, completely divided, each with a rough callous elastic cushion beneath,

and each protected at the tips with a strong hard hoof; these hoofs are short, and pointed at the tip, and are hooked down somewhat like a claw; they are compressed laterally, and the upper surface presents an acute ridge, sloping off on each side. The under surface is linearly concave, and consequently adapted for catching hold of any rugosity or projection. The llama's foot is thus fashioned as an instrument for clinging, or gaining a sort of hold in difficult passes, and this structure enables the animal to proceed with a free and fearless step. As in the camel the limbs are meagre, yet the llama will carry a weight of about one hundred pounds, and travel for four or five leagues a day.

So far have we hastily traced the modifications of the anterior limbs as they present themselves in ordinary quadrupeds. We find that when we descend the scale from man, though, in many instances, the paws or graspers retain a prehensile power, they cease to be organs of tact or touch. What, indeed, would the lower animals gain by such organs? what to them are the nicer qualities of matter to be learned by this sense? what have they to do with those unnumbered operations, to

which reason urges, and which demand the agency of the hand of man?

There is, however, still a modification of the anterior limbs, in mammalia, to which we must refer; we mean their conversion into paddles or oars for propelling the body through the water. We find this to be the case with the seal; but the seal can also shuffle along on the shore, or scramble over the surface of rocks; it has besides posterior limbs of a fin-like character, placed completely at the extremity of the body. In the whales and porpoises, on the contrary, there are no posterior limbs, and the anterior pair are far more completely paddles in appearance and structure. The bones are all imbedded in cellular tissue, and a smooth oily skin envelopes the whole, which is modelled into a short flat flipper, worked by muscles of great power and energy. There is in this instrument of aquatic propulsion not the slightest prehensile power; it is not even destined as a support to the body, but is merely fashioned as an oar; yet the female whale, when alarmed, can press her young cub between this paddle and her side, while she dives to avoid the assaults of her enemies.

The conversion of the anterior limbs into paddles shows to what an extreme the structural changes in their elementary parts may be carried; for although in the whale, the dugong, and others, the anatomist can determine the bones composing them, yet when we come to examine the paddles of those strange extinct reptiles of gigantic size, the plesiosaurus and the ichthyosaurus, we find them composed of rows of numerous small bones of irregular form, "polygons or trapezoids, less like phalanges, than the radii of the fins of a fish." In the pectoral fins of the fish, indeed, we see the last rudiments of the anterior extremity among the vertebrate classes.

How infinite are the resources of the Divine Mind! with what ease are the same organs fashioned into instruments for different purposes! Ingenious as are the contrivances of man, how few and feeble are they when compared with those of the Almighty! Man labours and studies and calculates, and produces a machine at once complicated and imperfect: others improve upon it; but still it is imperfect, and so it must ever remain. But the plans of the Almighty Creator surprise us

by their beautiful precision, their fitness, and their elegant simplicity. They proclaim their Divine original.

As in nature, so in grace is the wisdom of the Almighty seen. He is wonderful in counsel, and his purposes are wise and just and holy, whether they respect nations or individuals; there is nothing beneath his notice. In him we must put our trust, to him we must look, in all our trials, in all our difficulties, assured that he can deliver, that he can provide, and that the Cause of causes never wants the means of accomplishing his holy will. How often does human aid fail! how repeatedly are the designs of man frustrated! and if accomplished, with what difficulty! But all things obey God; he can give light in the darkest hour, and convert impending evil into good. We see and know only in part; but to God is manifest the past, the present, and the future, and it may be that the troubles of the present day are but the seeds of future joy and thankfulness. We repeat it then, as in nature, so in grace are the wisdom and goodness of God to be seen. Such considerations not only enforce upon our minds our perpetual dependence upon God, but lead us to repose

our entire trust in him, and in all his promises. He has shown his wisdom, power, and goodness in creation, but more than these, his mercy also, in the means of salvation (faith in the great Atonement), which he offers freely to all who feel their need of it. "God so loved the world that he gave his only begotten Son, that whosoever believeth in him should not perish, but have everlasting life." The brutes perish; but man lives in another state of being when his mortal body dies. He lives in happiness or misery: but the ransom for sin is paid. "Whosoever will, let him take of the water of life freely."

CHAPTER III.

ANTERIOR LIMBS OF BIRDS, REPTILES, AND FISHES

IN the wing of the bat we found the bones adapted for the extension of a sensitive membrane, the whole constituting an efficient instrument of flight. In birds, as a general rule, the anterior limbs are also constructed for flight, but in a different manner to what we see in the bat; for the efficiency of the wings depends in birds upon the extent and quality of the feathers of the pinions, which are acted upon by muscles of extraordinary vigour. If we look at the bones of a bird's wing we find them to consist of the upper-arm or humerus, the fore-arm with its two bones, the ulna and the radius; and a portion analogous to the hand, consisting of wrist-bones (*carpus*) supporting a thumb, two metacarpal bones of considerable length, and, lastly, the phalanges in a rudimentary state of two

fingers or their representatives, one composed of two joints, the other a mere rudiment. The shoulders are kept apart by the merry-thought or furcula, and the narrow blade-bones are further strengthened by two additional clavicular bones, which, joining one on each side with the breast-bone, oppose the inward strain of the powerful muscles of the breast. The bones of the wing of a bird constitute the framework, upon which the large feathers essential to flight are arranged and fixed firmly. Those on the fingers and metacarpus are termed primaries, and much of the power and character of the flight of the species depends on their form and elasticity. Those fixed on the fore-arm are termed secondaries; and those on the upper-arm are termed scapularies; but in many birds long slender feathers proceed from the elbow-joint, and are termed tertiaries; they are very observable in plovers, lapwings, curlews, etc. The thumb gives rise to short stiff feathers, constituting the winglet, or spurious wing. The extent of the wing thus produced, its general form, and the rigidity of the feathers, greatly influence the rapidity and style of progress in the air; and in some birds—as the ostrich, the emeu, the

cassowary, and others—the wings are altogether so undeveloped, that they are useless for flight, and the great muscular powers are consequently transferred from the chest to the thighs and haunches. Many birds use their wings as weapons, and in the jacana, the horned screamer, and certain species of plover, the shoulders are armed with very sharp, hard, horny spurs, capable of inflicting a severe wound. As among quadrupeds so among birds, we find some which have the anterior limbs transformed into paddles. This is the case with the great auk, (*Alca impennis*) a large bird inhabiting the arctic seas, and incapable of flight; nevertheless it uses its wings as oars, with great vigour and address, making its way so rapidly that a six-oared boat has been known to give chase in vain. In the antarctic seas, we have various species of penguins, in which the wings, covered with minute scale-like feathers, are even more admirably fashioned as oars. These birds swim submerged, using the wings much in the same way as the marine turtle its flippers. On shore the great Patagonian penguins sometimes assault each other, striking with the posterior edge of the wing; and Mr. Darwin

speaking of the jackass penguin, of Patagonia and the Falkland islands, says, "in diving, its little plumeless wings are used as fins, but on the land as front legs: when crawling, it may be said on four legs, through the tussocks, or on the side of a grassy cliff, it moved so very quickly that it might readily have been mistaken for a quadruped." This use of the anterior limbs for terrestrial progression, is very remarkable in a bird, though, in reality, not more so than the conversion of the anterior limbs of the bat into wings, which enable it to emulate the bird in flight.

While noticing the modifications of the fore-limbs in the bird and the bat, in order to render them available as organs of flight, we cannot help being at once carried forward to the class of reptiles, through a link now lost, namely, the pterodactyles of a former epoch—strange creatures, the existence of which, but for these relics, would scarcely have been imagined. These relics occur in the lithographic limestone of the Jura, in the lias of Lyme Regis, and the oölite of Stonesfield, and with them are mixed the remains of fishes, crustacea, and large insects. The species known by their remains, vary in size from a

cormorant to a snipe. By professor Blumenbach, these wonderful creatures were regarded as birds, and professor Hermann, of Strasburg, considered them to have been intermediate between mammalia and birds; but the opinion of Cuvier, that they are within the pale of the reptile class, is now generally received—winged reptiles pursuing their prey in the air! This latter philosopher describes them as reptiles, "whose appearance would be frightful did they occur at the present day," and of which "the principal characters are a very short tail—a very long neck—the muzzle much elongated and armed with sharp teeth, legs also long, and one of the toes of the anterior extremity excessively elongated, having probably served for the attachment of a membrane, adapted for supporting them in the air. Besides this, there are four (in some species three) other toes of the ordinary size, terminated by hooked claws"—to this we may add that the ribs are numerous and slender; and the neck variable in length and the character of the vertebræ composing it. In the long-muzzled pterodactyle, the jaws are exceedingly produced, but slender; the neck is long, and the vertebræ composing it are individually

elongated, like those of the neck of a heron; but the vertebral column of the back and loins is stout. In the short-muzzled pterodactyle, (a small species) the neck is much more abbreviated, and the head is much like that of a goose in miniature. In the thick-muzzled pterodactyles, the neck is long and extremely stout, the vertebræ being short and broad, with large processes; the rest of the skeleton appearing disproportionately small and feeble; but the anterior limbs are very long, and the finger (outermost) for supporting the supposed membrane is both stout and elongated. It is very evident that the different species varied greatly from each other in many details, as to their general appearance when alive, and perhaps as to their habits and manners also. In the long and stout-necked species, with a large head, most probably the membrane advanced principally from each side of the neck, so as to balance the animal in flight, and keep the head from being carried lower than the rest of the body. Dr. Buckland states, that in one species from the lias of Lyme Regis, we have evidence of an unusual provision for giving support to a large head at the extremity of a long neck, without

interfering with freedom of motion. This provision consists in the presence of bony tendons, which run along the cervical vertebræ to the head, similar to those which pass along the back of the pigmy musk deer, and also of many birds. Bony tendons, we well know, are often given, where great strength is needed, and the muscular strain upon them is considerable, as, for example, in the thighs of the turkey.

Of the habits of these singular reptiles we can only form a conjecture from their remains. It is generally believed,* that they flitted through the air in the chase of insects; but Dr. Buckland suggests that they might have enjoyed the power of swimming also, like the Roussette bat, of the island of Bonin; and that the larger species might have made fishes their

* After all, we are not quite sure that a true organ of flight was possessed by these animals,—it might only have been a large parachute, extending from the sides of the neck and body, including all the limbs, and having its outer margin supported and strengthened by the elongated finger-bones, which also assisted in neatly folding it up. The smallness of the body, the slenderness of the ribs, and the slightness of the haunch-bones, seem to confirm this view, affording, as it would appear, no provision for the attachment of muscles, which must have been voluminous, commensurately with the extent of the wings to be acted upon. We may, then, suppose these creatures to have been arboreal in their habits.

prey, darting at them as they rose to the surface, and carrying them away. He infers, besides, from the form of the posterior limbs, that they had the power of standing firmly on the ground, where, with their wings closed, they moved about in an upright attitude, somewhat like birds; but from the weakness and want of expansion in the haunch-bones, and from the deficiency of robustness in the vertebræ of the loins, we doubt this. It is, however, probable, that they could perch on the branches of trees, and scramble up the trunk, or up rocks and cliffs, by means of their fore and hind feet conjointly.

No reptiles of the present day have the limbs constructed for the purpose of flight. There are, however, certain little lizards belonging to India and its islands, distinguished by the startling name of dragons (*draco*) which have a wing-like expansion of skin along their side, and which is capable of being furled up, (somewhat in the manner of a fan,) and on the contrary, spread out. This membrane is supported by the false ribs, which are elongated, and also movable, at least so far as to fall back or be brought forward at pleasure, but not to be agitated so as to beat the air.

When at the full stretch, this expansion serves as a parachute, enabling the little creatures to take long skimming leaps from branch to branch, or tree to tree, like the flying squirrels, or the flying opossums of Australia. The contrivance is not to render them aërial, but more thoroughly arboreal in their habits. Although none of the reptiles of the present day are formed for winging their way through the air, many are adapted for the water, and have their limbs constructed for moving in the water, as we see strikingly exemplified in the marine tortoises or turtles, to which we have previously made allusion. In these animals, the flattened form of the body, and the extent of their compressed paddles, harmonize with each other very palpably, and combine to render every movement in the water prompt and easy. On the sandy shore, whither the turtle resorts for the purpose of depositing the eggs, its movements are awkward in the extreme; it shuffles along in the manner of a seal, forcing itself onward by reiterated strokes of its large paddles against the sand, but the moment it gains the water this toilsome method of making its way is over; it swims and dives, and ploughs the waves with infinite address; and

when seen deep beneath a boat in clear water, it reminds the spectator of a bird, winging its way with easy strokes through the air.

Many other reptiles afford us singular and very interesting examples of a modification of the feet, in order to meet certain exigencies; and in every case, according to the law of creation, the structure of the whole framework is in harmonious accordance. We have thrown out a hint that the pterodactyles may have been arboreal reptiles with parachutes, as are the little dragons, excepting that the limbs of the latter do not stretch the membrane; which they do in certain mammalia, namely, the flying squirrels and opossums, and that singular flying or sweeping lemur, the colugo, (*galeopithecus*,) all arboreal in their habits. There are, however, as we have seen, many arboreal quadrupeds destitute of these aids in taking long leaps, being provided in a different manner for the branches of the trees, as for example, the monkey and the sloth—and so among reptiles the same diversity prevails.

If we turn to the chamelion, an arboreal reptile which to a great degree seems in its class what the sloth is among quadrupeds, we shall find a curious modification of its limbs

for clinging, and retaining a pertinacious grasp. It is a slowly-moving creature, and seldom visits the ground, where its motions are remarkably strange and awkward ; it moves its limbs in succession in a groping, irresolute manner, as if hesitating before finally fixing them. The tail is round, tapering and strongly prehensile, and aids the clasp of the toes, which are five on each foot, divided into two opposing sets ; that is to say, three toes, united together nearly to the claws, are directed outwardly, and two, similarly united, are directed inwardly, (not anteriorly and posteriorly,) so that their grasp around a twig, or any object, is extremely tenacious ; the claws are sharp and curved. The chamelion is a clinging reptile, and all its actions are cautious and deliberate, no part of the animal moving with celerity, except its tongue, which it darts out at insects, and withdraws instantaneously. Other arboreal lizards, as the iguanas, have only large toes, rough, with granular points underneath, and furnished with long claws.

There is a curious tribe of nocturnal lizards, called geckos, from their clucking cry, which have the feet singularly adapted to their habits

and modes of life. They are climbers, but not arboreal climbers only; they run up the sides of walls, up the trunks of trees; they traverse ceilings like a fly, and cling to the under side of leaves; they make crevices in walls or buildings, holes in rocks, or fissures and hollows in trees, their resort, lurking there during the day. Night is the season of their activity; it is then that they come forth from their concealment, and wander in search of prey. Their eyes gleam in the darkness, and are intently fixed on any object that excites alarm or suspicion; and so prompt and rapid are these lizards in their movements, that they escape and vanish as if by magic, when their capture or destruction seems certain. For this mode of searching for prey, and for these quick and instantaneous actions, while running up walls or the trunks of trees, their feet are most admirably constructed. The toes are armed with sharp, retractile claws, like those of a cat in miniature, at least in most of the species, and moreover, on the under side, with suckers of various form and extent—in some oval, in some fan-shaped, and in others circular; and these suckers, acting like those on the feet of flies,

enable the animals to ascend smooth walls, and even fix themselves upon the ceilings of apartments. Nor are these lizards the only examples of this peculiar structure of the feet among the reptile tribes: there is a group of frogs, abundant in the warmer latitudes, which are arboreal in their habits, and remarkable for the beauty of their colouring. These frogs are extremely active and restless, and leap from leaf to leaf with admirable address. Often they lurk on the under side of leaves, and dart from their ambush at insects flitting by: they can clear distances of several feet, and attain with the utmost precision the leaf aimed at; there they settle, and sooner or later dart off to another. In these tree frogs, (and indeed on all the amphibious reptiles,) the toes are unarmed with claws, but each toe is enlarged at the tip, and is there furnished on its under surface with a cushion or sucker, lubricated with a glutinous fluid, and this sucker applies itself so closely to the surface it comes in contact with, as to retain the animal in its position, firmly attached. Nevertheless, these suckers are under the will of the animal, and can be disengaged or fixed at pleasure. It is from this power over its

suckers, that the fly walks so easily up a smooth pane of glass; in flies, however, each limb is furnished with two, or even three suckers, nor are these organs of adhesion confined among insects to flies only—they are found in many other tribes or groups of insects, differently arranged and modified according to the particular use they are destined to serve.

Still confining our attention to the vertebrate classes, we may now consider what structural modifications of the limbs are presented to us by fishes. We know that these creatures are formed for an aquatic life, and that they are furnished with fins on the body, and a tail-fin. "The total structure of the fish," says Cuvier, "is as evidently ordered for swimming, as that of the bird for flight; but the former, suspended in a fluid almost as heavy as itself, has no occasion for large wings in order to support itself. A great number of species have, immediately beneath the spine, an air-bladder, by the compression or dilatation of which, they can vary their specific gravity, and thus gain the power of ascending or descending. They proceed by the action of the tail, which strikes the water alternately

to the right and left; besides which, the gills, in throwing out the water backwards, also perhaps contribute to it. Limbs, then, being of subordinate use, are greatly reduced; the portions analogous to the bones of the arms and legs, are extremely shortened, or even entirely concealed, and rays, more or less numerous, sustaining membranous, swimming paddles, rudely represent the fingers and toes of the hands and the feet. The fins which represent the anterior extremities, are termed the pectoral; those which correspond to the hinder limbs, the ventral."

The pectoral fins are those situated one on each side of the body behind the gills; the ventral pair are situated generally nearly in a line below the former, and are close together on each side of the middle line of the under surface.

The resemblance of these fins to the ordinary limbs of quadrupeds, or even reptiles, which possess limbs, seems very remote; yet in several species, the rudiments of the various bones may be distinctly traced, and will be at once recognised by the anatomist. This is peculiarly the case in that singular fish, the angler or fishing-frog. In the pectoral fins, we

have the scapula, the clavicle, the two bones of the fore-arm, and the hand, divided into rays. Cuvier, however, regards the two bones forming a rude fore-arm, as really belonging to those which enter into the wrist at the base of the hand. The ventral fins are placed far anterior to the pectoral, and the gills inclose a large chamber, with only a small opening behind the latter fins, and are consequently capable of containing a supply of water, should it be needed. Mr. Yarrell, in his History of British Fishes, says: "The ventral fins, palmate in form, are placed very far forward on the body, and the pectorals, from their position, perform the office of hinder feet." "Upon the head are two slender, elongated appendages, the first of them broad, and flattened towards the end, and having, at this dilated part, a shining, silvery appearance. These elongated filaments are curiously articulated at the base, with the upper surface of the head; they have great freedom of motion in any direction, the first filament more particularly, produced by numerous muscles, amounting, according to M. Bailly, to twenty-two."

It will be interesting here to show how the structure of the limbs of this large and terrific

fish (*Lophius piscatorius*) are in consonance with its habits, which are predacious in the extreme, while it does not possess the powers of pursuit. Crouching close to the ground in the water, the angler, by the action of its limbs, or pectoral and ventral fins, stirs up the sand or mud, and lying then close, flat, and motionless, covered by the cloud thus raised, puts out his elongated filaments and moves them about in various directions by way of a bait. The glistening hue of the expanded end of the long shaft attracts some unfortunate fish roaming in quest of food, the angler plunges suddenly forwards and secures his victim. As the delicate skin covering the elongated shafts or filaments of bone is abundantly supplied with nerves, Mr. Yarrell suggests that they may serve the angler as sensitive organs of touch; and such is most probably the case, as they would thus indicate the approach of prey.

There is a fish closely allied to the angler for which we have no English name (it is the *Chironectes pictus* of Cuvier, the *Lophius histrio* of Linnæus,) even more remarkable than the angler. Its habits and mode of capturing prey are the same, and it can also carry in its capacious gill-chambers a supply of water. Hence it can

live for many days out of its element. On the land, it creeps along by means of its ventral and pectoral fins, almost like a small quadruped, the latter, which are placed in this fish posteriorly to the ventral, serving the office of hinder feet.*

How different in their structure and uses are the short, stout, arm-like fins of these fishes, from the expanded wing-like pectorals of the Indian flying gurnard, (*Dactylopterus orientalis*,) and the flying fish! (*Exocetus volitans.*) The

* There are in India and China, certain fishes of the genus ophicephalus, which are to a great extent terrestrial in their habits. The gill-chambers are so constructed as to hold a considerable quantity of water; and thus provided with a due supply, these fishes perform overland journeys of considerable extent; travelling to a great distance, by means of their fins, from their native water. The boatmen in India keep these fishes to make a show, and amuse spectators. Other fishes display the same habits. The paneiri *(Anabas testudineus)* of India, is said not only to leave the water, but to climb the shrubs along the margin of the river; and the gourami *(Osphromenus olfax)* of the Isle of France, but originally from China, leaves the pond or lake, comes on shore and digs a furrow in the sand for the reception of its eggs. This fish equals a turbot in size, and is excellent for the table. Terrestrial fishes were not unknown to the ancients. Theophrastus, in his treatise on fishes living on shore, speaks of certain species which leave the rivers for a considerable length of time, and then return. He says that they resemble mullets. Cuvier places the fishes to which we have alluded, in a distinct family, of the spine-finned section, characterized by the peculiar structure of the gill-chambers.

In noticing these fishes, we are reminded of the land-crabs of the West Indies and of India, which live in burrows, and only occasionally visit the water; of these the violet-crab, or toulourou, of the West Indies, is well known as a delicacy.

gurnards and the flying-fish belong to two very different sections of the class of fishes. In both, however, the pectoral fins are greatly expanded, and in the flying-gurnards, (*Dactylopterus*—Cuv.; *Trigla*—Linn.) as well as in the genus exocetus, are developed into beautiful and ample parachutes, by some regarded as wings. In their habits these flying-fish, whether gurnards or exoceti, much resemble each other. In the water they are pursued by dorados, dolphins, bonitos, etc.; and on rising into the air they are pounced upon by gannets, tropic birds, gulls, and others that hover over the teeming ocean, and derive their support from its exhaustless magazine.

It is easy to understand how it is that voyagers, little conversant with natural history, confound these air-skimming fishes under one term; nor can we always determine, in reading the travels of zoologists, to which fish their descriptions are intended to apply. It is most probably to the true flying-fish, (*Exocetus*,) that the following interesting observations by G. Bennett, esq., (see Wanderings, etc.,) are applicable. They convey a clear idea of the use of its vast but delicate pectoral fins.

"On arriving in the tropical regions, this

curious fish is seen, and affords some variety to the tedium of a ship: the passengers amused themselves by watching its flight, and sometimes its persecution, when pursued by bonitos, dolphins, albicores, among the finny, and tropic birds, boobies, and gannets, among the feathered tribe. I have frequently derived both information and amusement, by watching the flight of these fish, to observe them skim the surface of the water for a great distance, sometimes before, at other times against, the direction of the wind, elevating themselves either to a short height from the surface, or to five or six feet, and then diverging a little from their course, drop suddenly into their proper element. Sometimes, when their flight was not high above the water, and it blew fresh, they would meet with an elevated wave, which invariably buried them beneath it; but they would often again start from it, and renew their flight."

These fins quiver, we believe, as the fish skims along, though Mr. Bennett assures us, that he was never able to see any percussion of them; yet Cuvier, he observes, says, the animal beats the air during the leap, that is, alternately closes and expands its pectoral

fins. Dr. Abel also supports this opinion, as agreeing with his experience; and says, that he has repeatedly seen the motion of the fins during flight, and as flight is "only swimming in the air," it appears natural that those organs should be used in the same manner in both elements. To this, Mr. Bennett judiciously adds, that in fish the principal organ for propelling them through the water, is the tail, the fins serving to direct the course; that the structure of a fin is not that of a wing; and that the pectoral wings or fins of the flying-fish are simply enlarged fins, capable of supporting, but not of propelling, the animal in its flight.

"The greatest length of time," continues Mr. Bennett, "that I have seen these volatile fish on the fin, has been thirty seconds by the watch, and their longest flight mentioned by captain Hall, has been two hundred yards; but he thinks that subsequent observation has extended the space. The most usual height of flight, as seen above the surface of the water, is from two to three feet; but I have known them come on board at a height of fourteen feet and upwards, and they have been well ascertained to come into the channels

of a line-of-battle ship, which is considered as high as twenty feet and upwards.

"But it must not be supposed they have the power of elevating themselves in the air, after having left their native element; for, on watching them, I have often seen them fall much below the elevation at which they first rose from the water; but never, in any one instance, could I observe them raise themselves from the height at which they first sprang; and I regard the elevation they take to depend on the power of the first spring or leap they make on leaving their native element.

"The flight of these fish has been compared to that of birds, so as to deceive the observer. I cannot, however, perceive any comparison, one being an elegant, fearless, and independent motion, whilst that of the fish is hurried, stiff, and awkward, more like that of a creature requiring support for a short period; and then its repeated *flights* are merely another term for *leaps*. The fish make a rustling noise, very audible when they are near the ship, dart forwards, or sometimes take a curve to bring themselves before the wind, and, when fatigued, fall suddenly into the water. It is not uncommon to see them, when pursued, drop ex-

hausted, rise again almost instantly, proceed a little further, again dipping into the ocean, so continuing for some distance, until they are out of sight; so that we remain in ignorance whether they have been captured, or have eluded pursuit.

"The flying-fish swim in shoals; for, on one day, they are seen rising about, and, in the vicinity of the ship, in great numbers; and on the day following, or latter part of the same day, only a few stragglers are seen. When disturbed by the passage of a ship through the shoal, they rise in numbers near the bows of the vessel, and the consternation seems to spread among those far distant. The same may be observed when dolphins and albicores are pursuing them. On passing between the islands of Fuego and St. Jago (Cape Verd group) in December, 1828, I witnessed a number of bonitos in pursuit of flying-fish; the former springing several yards out of the water in eager chase, whilst large shoals of the latter arose with an audible rustling noise before their pursuers, and the chase continued as far as we could see, a number of victims, no doubt, being sacrificed to the voracity of their hunters. Besides the finny enemies, they had to encounter, as they rose from the water, boobies,

gannets, and tropic birds, which hovered about, and, in our view, secured very many as they sought refuge in the air. It was a novel sight, not often witnessed during repeated voyages, and afforded much amusement and interest to those who beheld it."

Such, then, is the wide extent of difference between the pectoral fins of the fisher, and the flying-fish. They present us with two extremes of structure in these organs, and yet how admirably are they in each case adapted to the habits, instincts, and necessities, of the respective animals! Thus it is that the structure of animals gives us a clue to their mode of life, while, on the other hand, organization is illustrated by an investigation of their mode of pursuing prey, and escaping from enemies, of the place they are destined to occupy in nature, and of the minor details appertaining to their history.

We have noticed the addition of suckers to the feet of various reptiles, enabling them to cling with the greater tenacity to the surface on which they rested; and among fishes we see a similar provision, but not always connected with the structure of the fins.

In that strange fish, the lump-sucker, (*Cy-*

clopterus lumpus,) often seen hanging up in the shops of London, the pectoral fins unite with the ventral fins beneath the throat, and form a single disc, constituting a sucker. By this apparatus, the lump-fish adheres firmly to rocks, or large masses of stone—a power the more needful, as it is slow in its actions.

"As the lump-fish," says Mr. Yarrell, "is retentive of life, its power of adhesion is sometimes made the subject of experiment." Pennant says, that "on placing a fish of this species, just caught, in a pail of water, it fixed itself so firmly to the bottom, that, on taking it by the tail, the whole pail, by that means, was lifted, though it held some gallons, and that without removing the fish from its hold."

In the month of March, the colours of the lump-fish are in the highest perfection, combining various shades of blue, purple, and orange; its flesh is at that time of superior excellence.

Two other British fishes, the unctuous sucker, and Montagu's sucking-fish, (*Liparis vulgaris*, and *Liparis Montagui*,) have the pectoral and ventral fins also united and surrounding a single disc. In two other British species, the Cornish sucker, (*Lepidogaster Cornubi-*

ensis,) and the bimaculated sucker, (*Lepidogaster bimaculatus*,) there are two suckers, one formed by a union of the two pectoral fins descending to the under surface of the body; the second by the ventral fins, which are united by a membrane below, forming a concave sucking disc. These fishes readily adhere to rocks or stones, and even to the hand when they are seized, which they cling to pertinaciously.

In the different species of remora, the fins do not enter into the construction of a sucker; but a large sucking disc, formed by numerous transverse cartilaginous plates, occupies the whole of the upper surface of the head. These fish adhere to others of larger size, and often to sharks, or the keels of vessels, and are thus carried about without exertion.

We may here notice the lampreys, in which the mouth is circular, and armed with hard tooth-like processes, while the lips, forming a continuous circle, act the part of a powerful sucker, as we see in the leech. These fishes attach themselves by the mouth to rocks and stones, and are thus enabled to resist tides or currents. Of these fish there are both marine and river species.

"In reference to the respiratory apparatus

Mr. Owen has remarked that, "when the lamprey is firmly attached, as is commonly the case, to foreign bodies, by means of its suctorial mouth, it is obvious that no water can pass by that aperture from the pharynx to the gills; it is, therefore, alternately received and expelled by the external apertures, (the gill-orifices along the neck.) If a lamprey, while so attached to the side of a vessel, be held with one series of apertures out of the water, the respiratory currents are seen to enter by the submerged orifices, and after traversing the corresponding sacs and the pharynx to pass through the opposite branchiæ, and to be forcibly ejected therefrom by the exposed orifices. The same mode of respiration must take place in the myxine, while its head is buried in the flesh of its prey."—Yarrell.

The sea-lamprey ascends rivers to breed, and produces pits and furrows in the bed to receive the eggs, by removing the stones with its suctorial mouth. The power of this fish is very great, and stones of a large size are easily transported, the furrow being rapidly formed.

Thus far, then, have we cursorily traced the modifications of the anterior limbs, (glancing occasionally at the hinder extremities also,)

from the hand and arm, as it is developed in man, to meet his exigencies as a rational being, through the various classes of the kingdom, till we come to the finny tribes of the waters. We have contemplated the clingers of the monkey, the diggers of the mole, the wings of the bat, the hooks of the sloth, and the armed paw of the lion. We have seen the solid pillars of the elephant, the elastic limbs of the horse, the foot of the camel and llama, and the paddles of the seal and the whale tribe. Again, in the wings of the feathered tribes, we have seen other modifications. We have pointed to some remarkable peculiarities in the structure of the feet of such reptiles, as, unlike the snake, are furnished with limbs, either for swimming or climbing, or adhering to smooth surfaces. And in some important modifications of the fins of fishes, we have pointed out the connexion between such modifications, and the peculiar habits of the species; and with this class of fishes the vertebrate series ends. In our progress, we could not but perceive that, receding only a few degrees from man, we began to find the anterior members less and less structurally constituted as organs of touch: less and less fashioned for manipulation or

for the investigation of certain of the properties of matter—but, on the contrary, modelled for very different purposes. Yet, as all the vertebrate animals are endowed with the sense of tact, (in contradistinction to that of mere feeling,) more or less nice and accurate, as may be required, and resident in some part or organ most suited to their wants and habits, we shall proceed, in continuation, to show some of the more interesting substitutes, rude though they may be, for the human hand, at once a grasper, a nice manipulator, and an organ of most refined touch.

It may be here said that we have made no definite remarks on the limbs of insects, or any of the lower orders of creation. We have not; for when we leave the vertebrate series, a strict structural comparison cannot be maintained. We are presented with forms of life on a different plan. We cannot compare them with animals endowed with a true spinal cord, a skull, a spinal column, and an internal skeleton.

Yet if any of these lower forms require our attention for a few moments before we proceed with our main design, it is the group of insects, so popularly termed, or, more strictly, the

crustacea, (lobsters, etc.,) *arachnida*, (spiders,) and *insecta*, (true insects.) All, however, which we can here say is, that in these classes, the limbs are modified for almost every conceivable purpose, for running, leaping, climbing, swimming, burrowing, and even striking. In the crustacea they vary greatly in form and size; in the lobster and its allied forms, they are divided into three sets. On each side of the mouth are six so-called limbs, termed jaw-feet, furnished with filamentous appendages as organs of touch. The use of these limbs is in the manipulation of food, and its application to the jaws. The true limbs are fixed under the chest, and are five on each side. The first pair are very large, and terminate in formidable pincers, acted upon by powerful muscles. In some crustacea the pincers are alike on each side, but not so in the lobster, the left being finely dentated, for the purpose of cutting; the right being bluntly tuberculated for seizing and holding fast. The pincers, both in form, use, and magnitude, vary very greatly in the crustacea, and in some groups lose the character of pincers altogether; the same observation applies to the form and development of the other limbs, which present incessant variation.

Following the true limbs and seated under what is called the tail, are five pairs of false feet, all, excepting the first pair, bifid at the last joint. These are useless as organs of locomotion; they are not encased in armour, as are the true limbs. Such is a brief description of the ordinary arrangement of the limbs in these mail-clad tenants of the waters, but it is totally inapplicable to the lower groups of these crustaceous animals, among which we meet with the most strange and singular of beings, as diversified in habits as in structure.

Passing to the *arachnida*, we find the sting-armed scorpion, with four jointed limbs on each side of the chest, besides a pair of crab-like claws, which are not limbs, but certain parts of the mouth developed, namely, the maxillæ; these are used for seizing prey.

In spiders, the limbs are eight in number; four on each side, and jointed into seven parts. The terminal joint is, in many species, furnished with two claws, having comb-like dentations, and a straight claw besides, with a saw-like edge. It is by means of these claws that the web-weaving spider stretches her lines, shakes her web, and glides along her filmy cordage, by these that she cuts away super-

fluous threads and coils them into a ball to be thrown away; by this apparatus, she brushes away the dust from her downy body, or cleans her network. From the delicacy of the operations performed by the spider in constructing her meshes, whether of close or open work, one cannot but think that the sense of touch is called into exercise, and that it is seated at least in the clawed joints of the limbs; even in the hunting spiders, which make no webs, and roam about in search of prey, upon which they dart like a tiger, their very mode of capturing their victims would seem to argue the same. We cannot, indeed, doubt that they possess a sense of touch, but to what extent, or how modified, we cannot tell; there is, in fact, something in the senses and instincts of spiders and insects generally beyond our comprehension. They perform labours which astonish us, and they, in many cases, act as if under the guidance of reason, rather than of instinct. In a certain sense, they are highly elevated in the scale of being, while in other respects they are far remote from animals with a brain and well-developed nervous system. In some cases the transfixion of their bodies occasions no symptoms of pain—they will thus eat and live;

but on the other hand who can watch a fly engaged in brushing its wings and back and head, and then rubbing its fore-limbs or hind-limbs together, as if to clean its suckers after being soiled, and not be convinced that it has the sense of touch? We have often been tempted to think that insects may possess senses unappreciable by ourselves, and undescribable because we are not endowed with them. Certainly it is strange that these brainless creatures, with a nervous system so simple, should be so quick, so prompt, so observant, so cautious, so skilful, should display memory and judgment, and be urged by anger or daring, or influenced by apprehension and fear.

Insects are organized for flight, and, besides the ordinary limbs, are furnished with two or four wings, (with certain exceptions,) of a membranous, and often extremely delicate tissue, marked by nervures which are regarded as air-tubes continued from the body. The extent and shape of the wings vary greatly —in some, the wings are smooth, transparent, and glittering; in others, they are covered with scales, or plumes of the most exquisite colours; and in others, as the beetle tribes, they are

folded up, when at rest, under wing-cases of a more or less rigid consistence. The ordinary limbs are six in number, each divided into five parts, of which the last, or foot, never consists of more than five joints. These parts are the hip, the trochanter, the thigh, the shank, and the foot, or tarsus.

Greatly are these limbs modified in detail in various insects. Some, elevated on long, slender, tremulous limbs, walk over and amidst the blades of grass as if elevated on stilts. Others have them expressly adapted for taking long leaps, as the grass-hoppers, crickets, and tree-hoppers: in some insects, as the fly, they are provided with suckers; in others they terminate in two hooked claws. Other insects again, of aquatic habits, have the hind limbs modified into paddles; many have the limbs adapted for climbing and clinging; many for running with great rapidity; some for a slow and heavy mode of progress, as the door-beetle; and some again for burrowing like the mole, as the mole-cricket, which well merits its appellation. Thus, then, differently as insects are organized from vertebrate animals, with respect to the general framework of their bodies, and the number, position, and conformation

of the limbs, still we find in the latter, analogous modifications to those presented by the limbs of mammalia, and for the same obvious reasons, to qualify the beings for certain modes of life, and peculiar habits. Differing in anatomical structure as the limbs of insects do, from those of the vertebrata, still a burrowing insect must have scrapers, and a swimming insect paddles; so we may say of the rest. At the same time, as we have observed, we cannot trace a series of structural modifications from the limbs of quadrupeds through those of insects, because insects are modelled upon a different type or pattern of organization entirely. As in the crustacea, their external integument serves the purpose of a skeleton, for there is no internal osseous framework.

Concluding with these remarks, we shall proceed to consider, as we proposed, the extent of the sense of tact or touch in the vertebrata, a sense which, residing *par excellence* in the hand of man, is transferred elsewhere in the vertebrata below him.

CHAPTER IV.

ON THE EQUIVALENTS OF THE HAND AS AN ORGAN OF TOUCH.

What we have already said respecting the human hand as an organ of touch, distinguished from what we term feeling, or a sensibility to agreeable or painful sensations, we shall not here repeat. We may, however, observe, that as this sense is not needed in great perfection by the lower orders, seeing that man only reasons, compares, and appreciates, so we must not expect to find it of extraordinary delicacy in whatever organ it may be seated among them, and in some it may be almost said to be absent.

In the monkey and ape tribes, which approach the nearest to man in their general conformation—the interval, however, being very great—the sense of touch undoubtedly resides in the hands. We see these animals try the hardness

of the shell of a nut by squeezing it, and we see them strike it with a stone, or hammer it on some hard surface, in order to break it; they will also endeavour to pick a lock by means of a bit of stick; they scratch their fur, and hunt for insects, seizing them with address; whence we at once infer that their hands enjoy this sense. The skin of the palms, moreover, is naked, and the cushion of cellular tissue there is abundantly supplied with nerves. In some of the lower American monkeys, however, the hands more resemble the paws of a squirrel, and perhaps do not possess a higher degree of the sense of touch, than they. This sense, in an imperfect measure, is enjoyed by most quadrupeds that freely use the fore-paws, as the squirrel and the beaver; and is seated in those organs. No one can see the dog scratch himself, or the cat dress her fur with her paws, without feeling that this is the case. Yet in the cat tribe, a far higher sense of touch is placed elsewhere. These animals are nocturnal, prowling by night for prey amidst thickets and dense jungles. On each side of the upper-lip, which is at that part thickened, are seated long bristles, called *whiskers;* they spring from a bed of closely-set glands under the skin, and

the root of each bristle is connected with a nerve. Hence they are important organs of touch. The cat stealing along in darkness, in order to invade the pigeon-loft or chicken-pen, is materially aided by these organs, which communicate an impression from the slightest contact with any object. They enable it to creep through crevices without running foul of any impediment, or to steal through tangled brushwood upon the bird or leveret, and thus combine with the power of nocturnal vision, and its springy padded feet, well armed for destruction, to fit it for its insidious habits.

In the bat, the membranous wings (and often also the external membranous ears) are, as we have before said, organs of refined touch; they are supplied with an exquisite mesh-work of nerves, and may be said to feel and try the quality of the air as they beat it.

In the mole, the coarse scrapers have, we apprehend, but a low sense of touch; in this animal, however, the snout is highly sensitive, and can be moved about very freely, in search of the worms on which the mole so extensively preys. In the burrowing mail-clad armadillo, it is also in the tip of the snout that the sense of touch resides, and perhaps, also, (as well as

that of taste,) in the long, slender extensile tongue; we have seen one of these animals examine objects by means of the tongue, which was applied with a quivering motion to every part of their surface. Perhaps, also, in the long tongue of the sloth this sense may reside, as well as that of taste. Let it be remembered that even in man the tongue is an organ of tact, often useful when the fingers fail: when the finest hair gets by accident into the mouth, our tongue can discover it.

A glance at the limbs of the elephant, the horse, the ox, the camel, or the deer, is sufficient to assure us that in no part of them the sense of touch resides. In these animals the limbs, as we have already pointed out, are mere instruments of support and locomotion, and, from the structural arrangement of the bones composing them, limited in their movements, the shoulder enjoying no power of rotation, the fore-arm no power of revolving. The toes, (or, as in the horse, the toe,) hoof-clad and rigid, are the fit terminations of such limbs, the uses of which are thus limited.

Let us first direct our attention to that ponderous beast the elephant. In this animal, the limbs, like rough pillars, support a massive

trunk and a huge head, while the weight of the latter, increased by heavy tusks, necessitates the abbreviation of the neck, which, if elongated, would give way beneath the load to be sustained. This shortness of neck prevents the elephant either from depressing its head to take food on the ground, or from raising it to browse on the leaves of trees. It requires an arm, and it has one: this arm is its trunk, or proboscis, at once an organ of touch, and an instrument of prehension. When we apply the term arm to the proboscis of the elephant, we do so in a figurative sense merely, for, strictly speaking, it is only a modification of the snout, or nasal termination carried to a very high degree, so as to constitute an available instrument, the consideration of which is very interesting. This proboscis consists of two canals, beginning at the nasal cavity of the skull, and divided from each other by a tendinous partition. Externally, it presents the form of an elongated cone, convex anteriorly and flattened posteriorly, the flattened portion having a rough projecting margin on each side at its junction with the convex, continued throughout its whole length. The anterior surface is furrowed by numerous transverse

wrinkles, which disappear the more that the animal elongates this organ; but when it contracts the trunk, or coils it in any direction, they are very apparent. The flexibility of the trunk of the elephant is astonishing, and this flexibility is owing to the multiplicity and arrangement of the muscles which compose it, and which, to the number of many thousands, cross each other in all directions, and act in obedience to the will. Hence it may be protruded or contracted, folded up or turned and twisted in every direction. Nor is its strength less remarkable than its flexibility; it can grasp bodies with enormous force, wrench off the branches of trees, or strike an enemy prostrate. With this instrument the elephant collects its food, and conveys it to the mouth, and by its means the animal also drinks. In the latter case the elephant sucks up the water till the two canals of the trunk are filled, it then turns the extremity of it into the mouth and there gently discharges the fluid. The animal can, however, throw the water out with great force, and in this manner often laves its own body, or the persons of by-standers, with a shower-bath. We may here allude to a contrivance for preventing the water taken into

the proboscis by suction from passing through the back of the nostrils into the throat, which would, indeed, take place, were it not for a movable cartilage acting as a valve, placed just anterior to the external nasal aperture of the skull, the closure of which effectually obstructs the further passage of the fluid. The proboscis of the elephant is not a rude and powerful grasper only, but is adapted for very delicate manipulation. The terminal orifices of the canals are encircled by a projecting margin, produced anteriorly into a muscular finger, of high sensibility. When we offer a biscuit or piece of bread to an elephant, the animal seizes it with this finger; the division between the orifices of the canals, and also their elevated margin, acting as the fulcrum against which it presses. With this finger, as we have often witnessed, can the elephant pick up from a smooth board floor a small silver coin, and restore it to the hand held out to receive it. We have said that there is meaning and silent eloquence in the actions of the human hand. With his proboscis the elephant begs, and threatens. Who that has visited the gardens of the Zoological Society has not been solicited for some delicacy by the elephant, or has misun-

derstood the actions of the raised up and then extended proboscis? Such, then, is the proboscis of the elephant—an instrument combining in itself the advantages of an arm an l hand, at once flexible, powerful, and sensitive.

Though among existing quadrupeds the elephant (under which term we include both the Indian and African species) has a proboscis thus developed, there are other animals which present us with a more or less close approximation to it, and among these we may particularize the tapir.

Distinct species of this animal inhabit Sumatra and South America. Their general form is hog-like, and the snout is produced into a flexible proboscis sufficiently developed to serve as a hook, or grasper, for drawing down twigs, or for grasping bunches of herbage, gourds, and other fruit, so as to direct them into the mouth.

In the common hog, the naked disc of the snout, with its elevated and movable margin, is endowed, to a considerable degree, with the sense of touch; and this is evidenced by the manner in which the hog uses the snout in ploughing up the soft earth, or in turning over and arranging the straw of the stye.

In the rhinoceros the upper lip is soft, fleshy, sensitive, and flexible, and is, moreover, capable of a certain degree of protrusion; it is, in fact, used as an instrument of prehension, or for directing food into the mouth. It is much in the same way that the horse uses his upper lip, when he feeds himself with hay. Every one must have observed the address with which the horse employs the lips, and how readily the last few grains of oats are picked up from off the bottom of the manger; or even from off the palm of the hand.

In the camel and the llama the upper lip is thick, deeply divided, and extremely flexible; it is, in fact, an organ of prehension as well as of touch. The camel feeds on the dry and thorny shrubs of the desert, on date-leaves, and the branches of the tamarisk. It lays hold of the twigs or tufts with its cleft prehensile lip, turning them into the mouth; and will even pluck off tender shoots and leaves with this fissured lip as we should with the fingers.

The giraffe is remarkable for the sensibility and flexible character of the upper-lip, which it can protrude and twist in various directions; it is used in the prehension of food. But the giraffe has an additional and most extraordinary

organ of tact and prehension in the tongue, which is, at the same time, endowed with mobility, sensibility, and taste. The tongue of this animal is long, slender, pointed, capable of being protruded to a great extent, and of being coiled round any object with the utmost precision. The giraffe uses it as a hook, or holder, to draw down the twigs of trees to its lips, and it is curious to see what power and address it displays. The giraffe browses on the leaves of the acacia and other trees, which it draws down to its mouth; and to one who pays attention to the philosophy of structure, its elevated forequarters, its long swan-like neck, its small head, large eyes, tapering muzzle, its prehensile lips, and grasping, twining, slender, and lengthened tongue, present a harmony of parts, well worthy of consideration. What a contrast do we see in this animal to the elephant, with its short neck and massive frame! yet in both, through a modification of different organs, is the same end attained; and both are enabled to seize the branches of the forest, which afford them sustenance, while above them, on some topmost bough, sits the four-handed monkey, gathering fruits or leaves with its hands.

In grazing quadrupeds, with an almost flat

and naked muzzle, the tongue appears to be the great organ of touch as well as prehension; cattle lick each other's coats with the rough surface of the tongue; but horses nibble or scratch each other's hides with the lips and front teeth. The cow has no fore teeth in the upper-jaw, and the tongue has much more freedom than that of the horse.

When we turn to the aquatic mammalia, whales, cachalots, and porpoises, with two paddles for limbs, and universally covered with a smooth oleaginous skin, spread over an under layer of blubber, we are at a loss to discover any organ in which the sense of touch more especially resides. This sense indeed they can scarcely be supposed to require, the diffused sense of simple feeling over the whole of the external surface is sufficient for their need; they dart through the waters after their prey, and seize it with a snap of the jaws, and swallow it instantaneously. Perhaps the tongue possesses some sense of touch, and this more especially in the Greenland whale, which feeds on myriads of small marine creatures, as the clio borealis and shrimps, which it takes in with a large volume of water, straining the latter off through the fringed edges of the plates of

baleen, or whalebone, ranged in close array along the upper jaw. The tongue of the species is very thick, fleshy, soft, fat, and spongy, and occupies a large portion of the cavity of the mouth ; it sometimes measures upwards of twenty feet in length, and eight or nine in width ; its mobility is very restricted, the tip not being free; nevertheless it is probably from some peculiar sensibility which it possesses, that the animal knows when to strain the water off, and swallow the myriads ingulfed.

So far among mammalia have we shown in what portions of the frame the sense of touch, and often of prehension also, are seated, when removed by the necessities of structural modifications, from the hand or anterior extremity. We have next to investigate in what degree birds possess this sense, and where it is seated in these feather-clad animals.

It does not appear to us that birds generally possess the sense of touch in anything like perfection. Sight and hearing are their most exalted senses, and to these they especially trust. They test nothing by feeling, nor is there need that they should, though to this rule there are certain exceptions. Birds,

such as the woodcock and snipe, which plunge their beaks into the ooze in quest of insects, have the sense of touch in great delicacy. In these birds the long beak is swollen, soft, and pulpy at the tip, where the skin is minutely dimpled, and supplied with a mesh of nerves, forming a tissue of high sensibility; it is decidedly by the sense of touch that the snipe, the woodcock, the ruff, the curlew, and other allied species, procure their food ; if we look at the bony fabric of the beak cleared of the soft pulpy skin which covers it, we shall find the tip riddled with minute and closely-set orifices for the exit of the nerves and blood-vessels. There is another tribe of birds, in which the beak and tongue are endowed with a very refined degree of the sense of touch—we mean the swans and ducks, and also the flamingo. In these birds the broad beak is adapted for groping in the mud; it is covered with a delicate leathery skin, and the edges are laminated, or furnished with closely-set transverse plates, acting as a strainer, and more developed in some species than in others.* In some spe-

* They remind us of the plates of baleen in the whale; nor is the tongue of the whale, and the flamingo or duck, very dissimilar.

cies of the southern hemisphere, the edge of the upper mandible is furnished with a thin membranous skin projecting considerably on each side, adding thereby to the breadth of the bill. The skin covering the bill, especially about the tip and along the sides, and the additional membrane, in such species as possess it, are supplied very freely with multitudinous nerves (from the fifth pair,) which endow it with most acute discriminating sensibility. In accordance with this sensibility of the beak, the tongue, instead of being thin and horny, as is the case in so many birds, is large and fleshy, and furnished along its margin, and on other parts, with somewhat rigid and comb-like appendages. It is abundantly supplied with nerves, and co-operates with the mandibles in the discrimination and the appropriation of its food. On looking at the skull of the common tame swan, now before us, we find the sides of the beak near the base, and the whole of the tip of the upper mandible, a middle line excepted, numerously perforated with orifices for the passage of nerves; and the tip of the lower mandible presents the same character. Those who have seen the duck probing and testing the mud, or watched the swan with his long

neck extended to the stretch, and buried in the water, the beak being at work in the oozy bed of the river, will feel convinced, on a moment's reflection, of the delicacy of discriminating sensibility which that organ must possess. Anatomy confirms the fact.

The woodpeckers constitute a group of birds in which the tongue is an essential agent in the acquisition of food. The tongue is long, flexible, capable of being protruded to a great distance, covered with viscid saliva, and armed with a horny tip, barbed on each side with minute spines directed backward. This instrument the woodpecker launches forth with great rapidity, inserting it into chinks and crevices where insects lodge, or into their cells and mazy retreats beneath the mouldering bark of trees, which the bird first lays open by strokes with its powerful beak; it catches them on the barbed and glutinous point, and draws them instantaneously into the mouth. The tongue of the woodpecker is at once a flexible sensitive probe, and an efficient agent in the acquisition of food. The same observation applies to the long worm-like tongue of the wryneck, which is covered with a glutinous secretion, and which the bird inserts into the crevices of the

bark of trees, in search of insects; ants are its favourite food, and at these it launches forth its tongue with wonderful rapidity, and also thrusts it into their retreats. We have frequently watched the wryneck, in captivity, dart forth its tongue and apply it to different substances presented as food, keeping it all the time in a state of rapid quivering.

The tongue of the humming-bird must also be regarded as a feeler or organ of touch; it is the instrument by which these gorgeous little birds obtain their food, and is governed in its movements by a peculiar muscular apparatus resembling that in the woodpecker. The tongue itself is very long, and composed of two cylinders of a fibrous and muscular texture, which are united together somewhat like the barrels of a double-barrelled gun; but towards the tip these tubes become separated, and terminate each in a little spoon-like expansion, concave within and convex externally; and these blades, when the beak is inserted into the nectary of flowers, not only lick up the honey, but also seize upon small insects, which are instantaneously drawn into the mouth and swallowed.

In the toucan, the large but light bill, the internal part of which is composed of a delicate

bony network, or cancellated structure, is evidently an organ of touch, being endowed with great sensibility. Throughout its internal cancellated structure branches of the fifth pair of nerves freely ramify, and the external horn of the back is so thin, notwithstanding its firmness, as rather to defend these nerves than intercept their reception of impressions. In these birds, the tongue is long, slender, flat, and horny, and furnished on each side with short processes like the vane of a feather. With this tongue the toucan often touches the food held between the two mandibles, and with apparent pleasure; consequently, we cannot but regard it as endowed with more sensibility than its structure would lead us to suppose. Fruit, eggs, and small birds form the food of the toucan.

Very different in structure are the beak and tongue of the parrot from those of the toucan. The beak is strong and solid, and the upper mandible freely movable; the tongue is thick and fleshy. That the latter is gifted with the sense of touch no one who has watched the mode in which these birds take their food can for a moment doubt. If we give a parrot a pod full of fresh peas, we may see with what address, holding the pod in one foot, it extracts

pea after pea; and each pea, before being eaten, is most cleverly divested of its outer layer or skin; and that by the aid of the tongue and beak alone, both entering into a manipulation, (if the term may be allowed) of great nicety. This would lead us to presume that the beak is by no means destitute of sensibility; and in the skulls of several species of parrot now before the writer, the furrows and orifices of nerves in abundance are clearly visible on the bones both of the upper and under mandible. The same observation respecting the beak applies also to the hard-billed finches, which are eminently skilful in disengaging seeds from their husks. If we watch a goldfinch or bullfinch shell hemp-seed by means of its beak assisted by the tongue, we shall not hesitate in admitting that the sense of tact in the beak is sufficiently elevated. In the crossbill, which extricates the seeds from beneath the hard scales of the pine-cones, and which has a peculiar modification both of the mandibles and also of the tongue, we have another example in point. Indeed, we think it may be laid down as a rule, that the sense of touch in birds resides in the beak or tongue, and often in both; at the same time, it must be confessed that in some birds,

for evident reasons, this sense is far more refined than in others; and that in none, perhaps, it is more discriminating than in the flamingo and duck tribe.

With respect to reptiles, the sense of touch, as contradistinguished from mere feeling, is scarcely possessed by any. Indeed, feeling itself is much more obtuse in these cold-blooded vertebrata, than in quadrupeds or birds; their tenacity of life is wonderful, and they bear almost with impunity injuries which would instantly kill one of the higher animals: a tortoise, for example, will move for days after being deprived of its head, and it is only by slow degrees that the irritability of the muscles ceases.

To these animals a delicate, or even tolerably developed sense of touch would be no benefit, and we cannot bring ourselves to agree with the opinion of a learned writer who says, "Serpents, from the great flexibility of their spine, are capable of grasping and twining round objects of almost any shape, and of taking, as it were, their exact measure. This conformation must be exceedingly favourable to the acquisition of correct perceptions of touch. As it is these perceptions which lay the foundation of the most perfect acquaintance

with the tangible properties of surrounding bodies, we may presume that this power contributes much to the sagacity possessed by these animals. It has been said of serpents that their whole body is a hand, conferring some of the advantages of that instrument." We allow, indeed, feeling to the body of the serpent, and admit that the reptile is fully conscious, from this sense, of the form or resistance of the object which it entwines ; so is the wrestler who entwines his limbs in the struggle around those of his antagonist; but the sense of touch is far higher than this diffused feeling, and we always suppose it to be concentrated in some organ, as the hand in man, the tip of the proboscis in the elephant. We are rather inclined to believe that in snakes, the slender bifurcated extensile tongue is the organ of touch ; we have seen the common snake use it as such, with a slight vibrating motion ; and we may observe that the boa, having crushed its victim, frequently touches the carcase with its forked tongue, its jaws dripping with saliva, whence has arisen the idea that this serpent lubricates his prey before proceeding to swallow it.

In the chameleon, the frog, and toad, which

launch their tongue at insects, (the mode in which they take their prey,) and attain their mark with extraordinary velocity and precision, the sense of touch, we can scarcely doubt, resides in that organ. In tortoises and turtles, we may, perhaps, look for this sense in some degree about the lips and muzzle, for, on touching those parts, they generally withdraw the head into the shell.

Fishes do not possess any special organs of touch, unless, indeed, the cirrhi, or barbels, of soft flesh about the mouths of some species may be considered as such, and also the long filaments which we have described as arising from the head of the angler, and with which it is said to entice its prey.

As we have adverted to insects, we may here take the opportunity of again noticing them, with reference to the sense of touch. We have alluded to the evident proofs of sensibility in the feet of the common fly; in the crane-flies also, the limbs are organs of touch; but in these insects the antennæ are short, for it is certainly in the antennæ generally that the sense of touch most eminently dwells.

Many insects, as they run along, make incessant use of their antennæ as feelers. The

ichneumon-flies keep their antennæ in perpetual vibration, and apply them to every object on which they rest. Bees employ their antennæ as feelers while building their combs, or storing them with honey in their dark hive; and wasps, in their underground retreat, are directed by them in the construction of their paper cells. Both these insects, and also ants, communicate their wishes, or information, to each other by touching each other in different ways with the antennæ, as though they employed a language of signs: it is by crossing the antennæ and striking lightly with them that bees communicate from one to another the news of the loss of the queen, which, when once made, sets the whole hive in tumult and agitation. If an insect be deprived of its antennæ, it either remains dull, senseless, and motionless, or else flies or wanders about as if distracted, and without any definite object. The bee ceases from its labours, and, wandering abroad, returns no more. The ant runs about in every direction, as if despair or frenzy had seized it. From these circumstances—that is, from the power of communication with each other by means of the antennæ, which insects enjoy, and from the lamentable consequences attendant upon their

loss—it has been supposed that some peculiar sense resides in them, to us totally unknown. Be this as it may, we cannot doubt that they are the organs of touch, and are extremely important; and that the insect is bewildered and incapable of exerting its instincts when they are removed.

Besides the sense of touch, that of hearing also appears to reside in the antennæ of insects, or is probably seated in some organ at their base. We say probably, for the question is still at issue; and though most naturalists allow that insects hear, (for by various sounds many make signals to each other,) yet all do not agree as to the situation of the organ of hearing. In some moths, Treviranus discovered a sort of drum at the base of the antennæ, behind which were nervous fibrils derived from those supplying the antennæ; in other insects, however, such an apparatus cannot be detected. It is remarkable, however, that in the lobster and higher crustacea, the organs of hearing are situated at the base of the larger antennæ, on the under side, where a tympanic membrane may be seen stretched across a little pit, having a slightly elevated margin. This cell or pit is filled with fluid, and a branch given off

from the nerve supplying the antennæ ramifies upon it.

The forms of the antennæ in insects are so multitudinous, that we cannot attempt here to describe them ; and with regard to the reasons for such extreme diversity, we must confess that they are not yet understood.

So far, then, have we followed out our subject. We began with the arm and hand of man, the leading modifications of which we traced throughout the series of vertebrata. We considered this portion of the frame in man not only as an organ of prehension, but also of touch, the latter gift rendering it perfect. We followed it as an organ of touch through the few animals nearest to man, and when, descending lower, we found this sense no longer present in the anterior extremities, we attempted to show to what organs it is removed by way of compensation, thereby exemplifying the consistency and propriety which are evident throughout the works of creation. In man it was shown that it was a great advantage that his hand should be the seat of the sense of touch ; in other animals this sense is wisely not so placed, but, on the contrary, allotted to other parts of the structure, in accordance with their necessities.

We introduced a digression on the limbs of insects, by way of comparison with those of quadrupeds; and, lastly, we have shown in what part of the frame of these wonderful creatures the sense of touch resides. Let us next proceed to the series of structural modifications as exhibited in the spine or vertebral column of the four great classes at the head of the animal kingdom.

Here, however, a few thoughts naturally suggest themselves from the details into which we have entered. How wonderful are the provisions which the all-wise Creator has made not only for the life and existence of the animal world, but also for its convenience and pleasurable sensations—for that kind and degree of happiness of which every living thing, in its degree, is capable! Hence we are led to infer that, could we ascertain more accurately the nature and character of our spirits, no doubt we should find that all is with equal wisdom and kindness provided for their highest interests, and we should discover that not a few of the circumstances of life have a far more important bearing than we can now trace out, on the advantage of the soul. These thoughts should also stop the

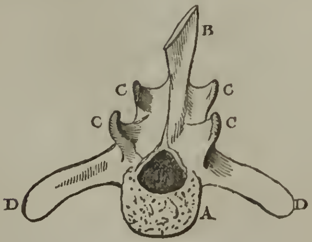
mouth of sceptics in reference to the plan of salvation; if there are mysteries in the organization of living beings—and who will presume to deny it?—mysteries in the work of creation—shall we disbelieve a scheme of redemption because it has its mysteries? Nay, should we not rather hesitate to receive it if it had no mysteries? As in the works of creation, so in the system of religion, the clearest facts, the plainest truths and precepts, which he who runs may read, are offered to our attention; but as in those works, so also in religion there are mysteries which baffle all the powers of the human intellect and confound man's boasted wisdom. Ours is the seat of humility.

The works of the Almighty, pregnant as they are with proofs of design, if studied aright, strengthen the Christian in his faith. "Ask now the beasts, and they shall teach thee; and the fowls of the air, and they shall tell thee: or speak to the earth, and it shall teach thee: and the fishes of the sea shall declare unto thee. Who knoweth not in all these that the hand of the Lord has wrought this? In whose hand is the soul of every living thing, and the breath of all mankind." Job xii. 7—10.

CHAPTER V.

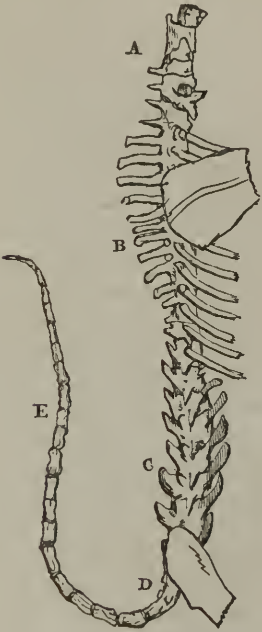
ON THE SPINAL COLUMN OF QUADRUPEDS.

WITH the condition of the limbs the structural modifications of the spinal column are in admirable accordance. The spinal or vertebral column consists of a series of bones (*vertebræ*)



conjoined together, each bone having a body (A), and certain processes, or additional parts,

encircling an orifice or open ring, so that from their apposition a canal is the result, continued



throughout the column, bounded anteriorly by the body of the bones, and posteriorly by the

processes. Of these processes, or projecting additions just described, one is termed the spinous (B), four are called the oblique (C), and two the transverse (D); and the vertebræ themselves are divided into those of the neck, A (*cervical*), those of the back, B (*dorsal*), those of the loins, C (*lumbar*), and those between the hip-bones, D (*sacral.*) To these follow accessory vertebræ in a rudimentary state, E, called coccygeal, or caudal; they run down the tail of quadrupeds, and are comparatively unimportant, and ever variable, as will appear by referring to the engraving of the spinal column of a lion. It is to the dorsal vertebræ in mammalia that the ribs are articulated. Each rib has its head fitted into a depression, formed conjointly by the bodies of two vertebræ, and is further united by a sort of tubercle to the transverse process of the lowermost of the two vertebræ to which its head is attached. To this mode of union among mammalia there are exceptions. In the whole tribe, for instance, the anterior ribs are each attached only to one vertebra by the head, and to the transverse process of the next by the tubercle, while the posterior ribs are attached exclusively to the transverse pro-

cesses. In that curious animal, the ornithorhynchus of New Holland, the ribs are attached solely to the bodies of the vertebræ.

The use of the spine is to give firmness to the general frame, yet consistent with ease and grace, and to afford a safe canal for the continuation of the spinal cord from the brain, which, as it passes, distributes through certain openings between the vertebræ nerves to the body and limbs. The mode of union in the mammalia between the separate bones composing the vertebral column is such as to endow the whole with considerable flexibility, while, at the same time, that the spinal cord may not be compressed, the individual mobility of each is very limited. It must be observed, then, that the bodies of the vertebræ are not in close contact, for, in this case, the column would be rigid, but there is interposed between them a substance of considerable thickness—a soft cartilaginous consistence, and highly elastic, to which the flexibility of the spine is owing. It is, in fact, from the interposition of these elastic cushions between the bodies of the vertebræ, (which are united together by the oblique processes,) that the flexibility of the spine is owing, so that the whole can be bent

forwards, backwards, or laterally to a greater or less degree, without an abrupt angle occuring in any part, to the injurious pressure of the spinal cord. The flexure is always formed by the concurrence of many vertebræ, and not of two, and the arch formed is gradual. Thus the hedgehog or the dormouse may roll itself up into a ball, without disturbing the great cord of nervous communication between the trunk and the brain. In man, who stands erect, the head is nearly balanced upon the spine; and thus he gazes around him, "monarch of all" he surveys; but his spine is not a straight column like a ruler, for then, though erect, his form would be destitute of grace, and his movements would be stiff and ungainly. It presents a series of graceful curves, that convert it into a perfect spring. The neck gently arches forwards, and thence between the shoulders takes a slight curve in the opposite direction, and again arches forward along the region of the loins. The vertebræ of the loins are the largest, those of the neck the smallest, and seven in number; and as the head is balanced, or nearly so, on the spine, requiring no strong muscles to sustain its weight, the processes of

the vertebræ are all moderately developed. In the lower mammalia, on the contrary, which may be called quadrupeds, the head acts as a dead weight at the extremity of the vertebral column, and requires to be supported by voluminous muscles, necessitating the enlargement and elongation of the spinous processes of the dorsal vertebræ; besides which, an elastic ligament, (called the cervical ligament,) running from the spinous processes to the back of the skull, contributes additional support, as it acts like a spiral spring. Quadrupeds in which the great power is concentrated in the head, neck, and shoulders—as the bear, or which carry heavy horns—as the African buffalo, or have a ponderous head, armed with enormous tusks—as the elephant, have these spinous processes greatly developed, and the neck is short. Still, however, it consists of seven vertebræ; and in the long neck of the giraffe of no more. If we turn to the spinal column of the elephant, we find the neck abbreviated, and the spinous processes of the dorsal and lumbar vertebræ elongated, and all inclined obliquely backwards. The vertebræ of the neck, though contracted in length, are voluminous and strong, and in every respect

well adapted for sustaining the weight of the skull; consequently, when the skeleton is clothed with muscles, and these covered with skin, the head appears as immediately resting on or against the shoulders. Let us contrast this modification of the vertebræ of the neck with those of the same bones in the giraffe. In this quadruped, the neck is extremely long and flexible, and sustains a small elegant head; accordingly, when we come to examine the skeleton, we find the cervical vertebræ extremely elongated, and not only so, for instead of their bodies being flattened and conjoined by the intervention of a cushion of elastic cartilaginous substance, they exhibit a series of ball-and-socket articulations; the ball which is on the anterior portion, or end of each vertebra, being received into the socket on the posterior portion of the one before it; and so on in succession from the seventh, or that adjoining the first dorsal vertebra, upwards to the head. This mode of articulation, which reminds us of the spine of a serpent, is evidently intended to give the utmost flexibility to the neck; and hence it is, that the giraffe wreathes it so gracefully in various directions. How beautifully accordant is this conformation of

the cervical vertebræ with the elevation of the limbs, the lightness of the skull, and the prehensile character of the tongue and lip; all tending to fit it for browsing on the leaves of the mimosa! From the length of the neck in this animal, the spinous processes, as might be expected, are extremely developed, and especially those forming the withers; it is, in fact, from the elevation of these processes that the back of the giraffe declines gradually from the shoulders to the crupper, producing, at a first glance, an appearance as if the animal stood higher before than behind, which is not really the case. The cervical ligament is enormously developed in the giraffe, and adds most materially to the ease with which the flexures of the neck are accomplished.

It is not only in the giraffe that the vertebræ of the neck are united by ball-and-socket articulations; we find in another long-necked quadruped the same provision, namely, in the camel; remarkable also for the flexibility of this portion of the frame.

When we say that the cervical vertebræ are seven in number, we must not forget that there are exceptions to this rule, both by way of increase and decrease. The three-toed sloth is

an instance of the former. We have already commented upon the limbs of this animal and its singular mode of life; it hangs attached to the branch with the back downwards. A long neck in such an animal would be out of place; yet, in order that it may gaze freely, not only around it on each side, and above, but also survey the ground below, some provision is requisite; and, accordingly, the great mobility of the neck is secured by the addition of two vertebræ, making nine. Mr. Bell, indeed, (Trans. Zool. Soc. Part I. 1834,) regards the eighth and ninth vertebræ as really belonging to the dorsal series, in consequence of their having a small bony appendage, considered to be a rudimentary rib, attached to each, on both sides. This, however, matters little; they enter into the bony structure of the neck, adding two joints more without materially elongating it. Hence this animal can twist its neck round and look downwards, or fold it so as to place the head between the arms on the chest. "Mr. Burchell has observed (says Dr. Buckland) that this animal can in a remarkable manner, and with great facility, twist its head quite round, and look in the face of a person

standing directly behind it, while, at the same time, the body and limbs remain unmoved. As the creature thus embracing and attached to the trunk or branch of a tree can keep no look-out in front, the increased flexibility arising from the position of these two anterior dorsal vertebræ (cervical ?) may be considered as a compensation, enabling it to see and guard against the approach of its enemies, in flank and rear, as well as to see the position of its food. The habits of the sloth are unique among quadrupeds, and so also is this compensation. Another advantage arising from this unusual flexibility may be to afford ease to the neck, under the peculiar position which the sloth assumes in taking its repose. In the case of an animal, a great part of whose life, when not engaged in eating, is spent in sleeping on trees, an easy attitude for repose is most essential to its comfortable existence; and, accordingly, we find that the auxiliary vertebræ at the base of the neck contribute to produce that flexibility of this organ which allows the head of the animal to incline forward and rest upon its bosom."

It is curious to compare the swan-like neck

of the towering giraffe, or the flexible neck of the sloth, with that of the whale or porpoise. The contrast is in the extreme.

Let us consider the habits and general form of these aquatic mammalia. Their body elongated, conical, and somewhat fish-like, is covered with a naked oily skin; their fore-limbs are converted into paddles; hind-limbs are wanting, but the elongated posterior part of the body terminating in a broad horizontal flipper is endowed with enormous power, enabling them to lash the sea into foam. The head appears to be a mere anterior portion of the body, continued in the same line and unseparated by a neck — nor is it movable independent of the body. These are animals that plough the waves, that urge their course through the trackless waters, head foremost, with tremendous velocity. Their head, like the prow of a vessel, has to meet and overcome the resistance of the fluid medium—hence the fish-like immobility of the head, and absence of apparent neck. In these marine creatures, the cervical vertebræ are wedged together within the smallest possible compass; and not only so, many of them are consolidated into one piece. In some species, only six cervical vertebræ

appear to exist; although, from the consolidation of several into one, some error may have arisen in counting them. However, according to Steller, Cuvier, and Meckel, in that singular aquatic herbivorous animal, the lamantin, (which feeds on sub-marine vegetation,) there are only six.*

When we regard the ponderous head of the whale, its position with respect to the body, and the resistance of the water which it has to overcome, as the animal propels itself along, we at once appreciate the reasons for the contraction and immobility of the cervical vertebræ; these points are in keeping with the rest of the organic structure. This characteristic abbreviation of the neck is seen in the remains of that strange extinct animal the ichthyosaurus; but in the plesiosaurus, on the contrary, the neck is very long, equalling, if not exceeding, the length of the rest of the body—most probably the animal swam about, with the neck elevated, like that of a swan, above the surface of the water, while the head was held in readiness for being launched, with open jaws, upon passing prey.

* The lamantin and dugong are not of the whale tribe—they are really marine pachydermatous animals, though Cuvier calls them herbivorous cetacea.

In mammalia, the dorsal and lumbar vertebræ are variable in number—the former, according with the number of ribs on each side. In the elephant and tapir, the dorsal vertebræ are twenty in number; in the rhinoceros, nineteen; in the dugong, eighteen; in the horse, eighteen; in man, twelve; in the chimpanzee, thirteen; in the porpoise, thirteen; and here we may observe that in the whale tribe, as respects the rest of the vertebræ, no definite line of demarcation separates between the lumbar, sacral, or caudal.

It will be interesting, here, to notice the degree to which, in harmony with the limbs, the character of the spinal column in mammalia influences their style of locomotion. The following passage is from the fragment of a work on the "Natural History of Quadrupeds," by the present writer: "With respect to the spinous processes of the lumbar vertebræ, they are less elongated than those of the dorsal, and especially of the anterior dorsal vertebræ; and, in general, their direction is opposite. The spinous processes of the dorsal vertebræ point obliquely backwards; those of the lumbar vertebræ obliquely forward; at least, as a general rule. Whence it would seem to follow

that, at the point of junction between the dorsal and lumbar portions of the vertebral column, the spinous processes of each part must meet in abrupt opposition. This, however, is not precisely the case; for if it were, the centre of motion in the spinal column would necessarily lie between two vertebræ, and the flexure would be acute. There is a transition from the posterior-oblique bearing of the spinous processes of the dorsal, to the anteriorly-oblique bearing of those of the lumbar vertebræ; the processes of the lower dorsal and upper or anterior lumbar vertebræ gradually assuming a horizontal direction in man, or a vertical direction (according to their attitude) in quadrupedal mammalia. So that, instead of being confined to one point, the centre of motion is diffused over the space of the three or four last dorsal, and two or three first lumbar vertebræ, an abruptly acute curve being thus avoided.

"Professor Owen observes, that 'the relation which the structure of the vertebral column bears to the mode of a quadruped's locomotion is extremely interesting, and enables us to judge, in some degree, from the spine alone, of the locomotive faculties of a fossil species. If we attend to the progressive

motion of any heavy animal, as the ox, we shall find the flexibility of the vertebral column—at least of its dorsal and lumbar portions—to be very restricted, and its centre of motion indefinite: it seems destitute of that suppleness which we see so marked in the weasel or the cat. Now if the dorsal and lumbar vertebræ be examined, they will be found short, and with only a thin layer of elastic cartilage intervening between their bodies, while their large strong spinous processes have no point between them to which they definitely converge. In animals endowed with great flexibility of body, as the cat, the leopard, and others, this converging point is clearly marked, and the oblique bearing in an opposing direction of the dorsal and lumbar vertebræ is very decided: added to which the bodies of the vertebræ are comparatively longer, and the layer of cartilage interposing between each is of greater thickness relatively than in the ox. Some animals have no centre of motion in the back, as the armadillo, the chlamyphorus, etc., and in these, the spinous processes are all directed backwards; (we may here add that such is the case in the elephant.) The progressive motion of such animals is

automaton-like: their legs seem to go by machinery, which affects no other part of the body. No inflections of the spine accompany the movements of the limbs. The two extremities of the vertebral column are not alternately raised and lowered as in the bounding leopard; but the back preserves its uniform level, however rapid may be the motion of the limbs. It is from this circumstance that the rapid movements of the armadillos in the gardens of the Zoological Society of London have never failed to excite surprise." Thus, then, between the structure of the limbs and that of the spine there is a beautiful accordance, and, in fact, the observation may be extended, for no part of the animal framework is independent of another. And hence it is that a single bone of importance is, as it were, a key to the rest of the framework. Guided by this principle, the illustrious Cuvier undertook the investigation of fossil relics, and, in numerous instances, from the careful consideration of two or three bones, pictured what the whole must have been, with an accuracy which subsequent discoveries have confirmed. This mastership, however, is the result of profound study, of long research; nevertheless, that a

skeleton may be restored, from a careful examination, we may say perusal, of its fragments, is a proof of the law of harmony. The law of harmony supposes design, skill, power, and hence are we directly led from the creature to the Creator. Many of our readers have seen, no doubt, a humorous picture by Hogarth, in which the rules of perspective are purposely violated, an incongruous assemblage of objects being the result. Such a chance-medley affair would be the structure of every animal, were the laws of harmony violated, or not observed; and in vain from any portion, might the most accomplished anatomist endeavour to reconstruct its fabric of a given species, for he would work in darkness, without rule, or any possible guide; but, as it is, one bone proclaims what another must have been, and thus may the anatomist add part to part, till, the minor details alone excepted, the fabric is rebuilt.

CHAPTER VI.

THE SPINAL COLUMN OF BIRDS.

Keeping in mind the law of harmony, let us turn from quadrupeds to birds.

Birds are formed for flight: of the four limbs, the two anterior are modelled into wings, and the posterior, with few exceptions, are organs of motion on land, or in the water; and if we look at the skeleton, will be found to be articulated to it almost at its posterior extremity, so far removed is the hip-joint from the fore-part of the chest. The structure of the wings for flight not only supposes powerful muscles, but a firm, unyielding basis on which to act. Consequently, we find the shoulders kept apart by the furcula, or merry-thought, and pushed forward from the deep and ample breast-bone, by a large coracoid bone, while a narrow blade-bone extends over the arch of the ribs; but this is not all, the dorsal ver-

tebræ are ossified together, consolidated into one, though each preserves its distinctness of outline, and little splints of bone derived from the transverse processes overlap each other, and thus add to the strength of this portion of the vertebral column. It is rigid and unyielding. To this part the true ribs are attached, bending thence round to the breast-bone, on the margin of which they are inserted. But even the ribs have to be strengthened, and this is effected by a broad flat process, projecting from the posterior margin of each rib: at the central part of the arch it forms, and prolonged backwards and upwards so as to overlap the next rib in succession. In some birds these processes are more bold and decided than in others.

When we pass from the dorsal vertebræ, we find the lumbar and sacral vertebræ uniting with the hip or haunch-bones, to form one large solid portion, every part being consolidated together. Now if we consider the backward position of the legs, and of the hip-joint, and reflect that these limbs thus disadvantageously placed, inasmuch as the bird is not balanced upon them, have to sustain on the ground the weight of the body, we shall

immediately see that a solid unyielding foundation must be laid for the attachment of the voluminous muscles of the thigh. The thigh, as we have said, is articulated far beyond the centre of gravity, the body is carried more or less horizontally; consequently, without an adequate muscular power to sustain its weight in this position, it would sink till the chest touched the ground. Indeed, in some instances, as the great auk and penguin, the bird cannot maintain a horizontal attitude, so far back are the short limbs placed, but is obliged to raise itself into a perpendicular position as long as it remains on the land. The jackass penguin, as we have said, does, indeed, lean forward, overbalanced, but then it uses its anterior fin-like wings as crutches, and so runs on all fours. In like manner the grebe is overbalanced, and is unable to raise its body up. The breast feathers of this bird are exceedingly close and silky, and, resting on the ground, it slides along, like a seal, pushing itself forward by means of its hind-feet, which are each tri-oared. This extreme backward position of the limbs, however awkward it may render the birds on land, conduces most eminently to their advantage in the water.

Of the caudal vertebræ of birds little need be said; they are small with marked spinous processes, but the last is enlarged and compressed, and termed the ploughshare. The vertebræ of the neck, however, require more consideration. If we except the parrot and a few more birds, the only organ of prehension which these animals possess is the bill, and in connexion with this the neck may be regarded as a sort of flexible arm; without it, the use of the bill would be very limited. It is by means of his long slender neck, that the patient heron darts his beak with arrow-like rapidity at passing fish. The swan is enabled, by means of his long neck, to explore the muddy bottom of the lake or river; and, even in birds with far shorter necks, which feed in a similar manner, still a certain degree of length, and great mobility, are necessary. It is among the waders, and the duck tribe in general, that we find the neck the most elongated, and the vertebræ composing it the most numerous; for, be it observed, the vertebræ composing the part in birds are very variable. In the swan, there are twenty-four cervical vertebræ; according to Cuvier, the stork and crane have nineteen cervical vertebræ; in the

grebe there are eighteen or nineteen; in the great penguin, thirteen; in the sparrow, nine. In the waders, swans, and other very long-necked birds, the cervical vertebræ are themselves of a far more elongated form than in birds with shorter necks. The cervical vertebræ are united together in a simple manner; there is no elastic cushion between the bodies of each, but they are connected by articulating facets, (one on each side,) and at each inclosed by a capsule or membrane; these opposing facets have, however, a little smooth cartilage between them in order to facilitate their movements. We have spoken of the neck of birds as constituting a sort of many-jointed arm; and, like the arm, it subserves another purpose besides that for which it is primarily designed—it acts as a balancer. We have seen, from the position of the hip-joint, the tendency of the body to fall forward. This tendency may be partially counteracted by drawing back the head. In terrestrial birds, as the fowl and turkey, the head is ordinarily drawn considerably back, as they move quietly about. It is so in the duck also; birds with long legs and necks—as the heron, the stork, the Marabou crane, and others—stand

almost upright in their common attitude, at rest, with the head drawn back and laid between the shoulders. Most birds during repose throw the head back, bury it in the feathers beneath the wing, and support themselves on their perch by means of one leg only. Thus they regulate the position of the centre of gravity.

On the contrary, during flight, the bird stretches forward its neck, in order to keep its balance true, that is, to bring the centre of gravity under the origin of the wings. In some very long-necked birds, as the heron, the neck is folded during flight, and the spear-like bill directed forwards. This use of the neck in balancing the body is precisely the same as that of the arms, under various circumstances. If we stand on one leg, and bend the body to the right, the left arm will be involuntarily extended, from an instinctive perception that by so doing the balance will be maintained. When children in play hop on one leg this management of the arms in preserving an equilibrium may be seen in continual operation. This involuntary and instinctive action is the result of a peculiar "muscular sense," which leads us to adjust the frame so as to

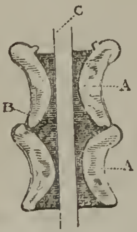
correct its deviations from the perpendicular; or to preserve a due balance. Sir C. Bell regards this as a sixth sense, "essential to the exercise of the sense of touch."

Again; birds are clothed with plumage, and employ their beaks in arranging and dressing it. The length and mobility of the neck, afford them an advantage, in this respect, of no trifling importance.

It is not only the neck, in the bird, which is so free and unconstrained in its actions, for the head, independently of the neck, enjoys the facility of turning from side to side, or indeed so much round, that the position of the beak is reversed, and points over the back. Many, doubtless, have observed the odd motions of the head which the owl is in the habit of making, and how frequently it will turn its broad face over its back, as if its neck were screwed round. This freedom of the head arises from its mode of union with the first cervical vertebra. If we look at the skull of a bird, we shall find, on the anterior margin of the great orifice which admits the exit of the spinal cord, a single tubercle; now this tubercle is received into a corresponding little pit, or socket, on the upper end of the first

vertebra, anterior to the spinal canal; so that, in fact, the head turns on a pivot, the freedom of which is restricted by ligaments. In mammalia, there are two articulating convex surfaces on the occiput, received into corresponding depressions in the first vertebra, (*atlas*,) and this revolves on the second vertebra, or rather upon a process of the second, termed the odontoid, or toothlike process; but the power of turning the head, except in very long-necked quadrupeds, and the sloth, is comparatively limited. As the bird bends its neck at surprisingly abrupt angles, it will naturally be asked how it happens that at these angles the spinal cord escapes compression, which would either destroy life, or paralyze the whole frame: if we run a thread or string through several short pieces of a tobacco-pipe, and make a sudden angle between any two, we shall find the string to be pressed upon and strained at that angle, and so it would appear must be the spinal cord of the bird under similar circumstances; and, indeed, so it would be, but for a special provision, a provision which expressly proves the care and forethought (so to speak) of the great Creator in his works. Nothing can be more simple than the plan adopted—

yet nothing more effectual; the canal which traverses each vertebra, is not of the same uniform diameter throughout, but is much larger at each end of the bone, whence it contracts gradually to the centre; its diameter at the centre is just adapted to the size of the cord and its sheath; but at each extremity it is much larger than would be needed, were no flexures of the whole column to be made. The annexed rough diagram supposes a section of



two cervical vertebræ. A, the vertebræ; B, the spinal canal; C, the spinal cord. Now, the central narrowness and the gradual expansion of the canal through each vertebra, tend to accomplish the following object—namely, the susceptibility of a great flexure of any two given vertebræ at their joint, without compressing the spinal cord, and indeed without bending it in an equal ratio; in fact, the

diameter of the canal at the flexure is not reduced beyond that of its narrow portion. Thus is the safety of the bird provided for, and the needful mobility of the neck preserved. From the experiments of Mr. Earle, it was found that the vertebræ thus constructed, might be bent backwards even to a right angle, and laterally to the extent of half a right angle, without injury to the inclosed spine.

It is in facts like this—in minute details of structure, easily comprehended by the most ordinary intellect—that the power and wisdom of God are so clear and palpable. When we attempt to grasp mentally the great scheme of creation, weigh the bearings of one portion on another, and moot the final causes of organic life, our mind recoils from the task; we feel our weakness, and are lost in amazement. But when we come to the examination of structure, and at every step meet with proofs of care, skill, and design, we feel delighted and refreshed as we pursue our way, and trace the hand of God in the works of this lower world. So, too, is it when we contemplate the scheme of salvation; the truths essential for us to know and believe are clear and direct, and are cal-

culated to strengthen and refresh us in our journey through life. Plain is the gospel plan as unfolded to us ; but its great mysteries are beyond the utmost stretch of our minds—these we see through a glass darkly ; in vain we try to penetrate into the secrets of the Eternal Mind. Let it suffice us that all that is needful is revealed ; and that those things which now we know not, we shall know hereafter.

CHAPTER VII.

THE SPINAL COLUMN OF REPTILES.

Leaving the birds, the various reptile tribes next demand our notice. The difference in form and habits between the numerous groups into which the reptiles are divided is very great. Some have four limbs, some only two, and some none. Some are clad in strong armour, some are clad with scales, and some are naked. Some are terrestrial, some aquatic, and some arboreal. Some dart along with wonderful rapidity, others are sluggish and heavy in their movements. Many are capable of writhing and twisting their forms into various curves or flexures; others have no movements excepting those of the head and limbs. Under all these circumstances great modifications in the character of the spine may be expected, and nothing affords a more decided contrast than that of the tortoise compared with that of the serpent.

Few persons who look at a tortoise consider that the shell, as it is termed, into which the animal can withdraw its limbs and head, consists, in reality, of a great portion of the skeleton developed externally, and modified into a box or case in which the muscles, the bones of the shoulders, and hips, and the viscera are inclosed; this box is covered with horny plates, sometimes with a leathery membrane. The arched upper portion of this case is termed the carapace, the lower is called the plastron. Now let us see what the carapace really is, and of what it is composed. If we remove the plastron, we at once perceive the dorsal portion of the spinal column running down the centre of the concave inside of the carapace, and consolidated to it so as to be immovable; the individual vertebræ, however, may be readily distinguished—they are small and elongated. On looking more narrowly, and supposing the horny plates on the outside to be removed, we find a series of bones, united together by suture like those of the human skull, running down the central portion of the carapace—these bones are the processes of the vertebræ thus strangely altered from their ordinary form and appearance. On each

side of these flattened expanded processes, and united to them and to each other by suture, is generally, but not always, a range of longer bones—these are evidently the ribs, as may be clearly seen by looking at the spine, where the way in which they proceed from it is manifest. Here, then, we have a large shield, formed not by new elements, not by bones or parts of bones unknown in other animals, but by modifications merely of structural detail. But the carapace is not yet complete; it is margined all round with another set of flattened bones, united to the rib-plates, and generally regarded as the analogues of the sternal ribs of the crocodile.* Perhaps they are analogous to the sternal portion of the ribs in birds, which is bony, and not, as in the ordinary mammalia, cartilaginous.†

The carapace is united at its sides to the plastron, which unquestionably represents the breast-bone.

Thus modified, the dorsal portion of the spine of the tortoise, it need scarcely be said, is

* Ribs arising from a prolongation of the long narrow breast-bone for supporting the abdomen.

† In the ornithorhynchus the sternal portion of the ribs is osseous as in birds.

destitute of mobility; and the heavy lumpish movements of the animal, without the slightest elasticity or grace, are in keeping with this inflexibility of that portion of the spine. The neck, however, is at liberty, and capable of being protruded or withdrawn and of being bent in various directions, the ball-and-socket articulations of the vertebræ being very free. The same observations apply to the vertebræ of the tail.

Considered with regard to their skeleton, the greater portion of which is, so to speak, thrown outwardly, tortoises are most extraordinary creatures, and we know of no vertebrated animals which resemble them. Among mammalia, the armadilloes are covered with a shield, and the manis with an armour of thick scales; but in these cases, the plates and scales are, like hairs or feathers, derived exclusively from the integument, and have nothing to do with the osseous frame-work. So, again, among fishes, we see the ostracion, or box-fish, invested with an inflexible coat of mail, composed of osseous plates united together, covering the whole body, the tail and fins alone being free. Yet the box-fishes cannot be compared to the tortoises—for osseous as is their invest-

ment, it is still a cutaneous production, and not an integral portion of the skeleton.

From a consideration of the tortoise, boxed up in its own skeleton, let us now turn to the snake, with a view to ascertain the mechanism of its vertebral column. These long, tortuous creatures are destitute of a breast-bone and of limbs, except, that, in the boa, rudiments of posterior limbs in the form of spurs, consisting of a few bones acted upon by muscles, are seated just anterior to the base of the tail. These spurs aid the tail in grasping; for in these snakes this part is strongly prehensile, and often firmly lashed round some fixed object, while the huge reptile lies in wait for its unwary victim.

The skeleton of the snake is very simple, but at the same time very elegant: it consists only of the head, the vertebral column, and the ribs. From the extreme flexibility of these animals, we are naturally prepared to expect certain modifications of structure, in the osseous fabric, whence this freedom of motion arises; but here, as in all similar cases, simplicity pervades the whole. Three points may be noticed: the sub-division of

the spinal column into an amazing number of distinct portions or vertebræ—the nature of the articulation of these vertebræ—and the lax and peculiar attachment of the ribs. With respect to the number of vertebræ in different snakes, it varies in different species, and all, excepting the two or three first, and those of the tail, are furnished with ribs. Professor Jones enumerates three hundred and four distinct vertebræ in the boa constrictor, of which two hundred and fifty-two support ribs. The spine of the common ringed snake is composed of more than three hundred vertebræ, and that of the rattlesnake of above two hundred. We do not know that the vertebræ in any of the long, slender tree-snakes, have been counted, but they must be extremely numerous.

With respect to the articulations of these vertebræ, we may observe that they are on the principle of the ball-and-socket; and in this manner both pliancy and strength are combined. On examining each vertebra, we find that its anterior extremity is hollowed out into the form of a cup or deep depression, while its posterior extremity is rounded into a smooth and polished ball; this ball is received into the cup at the anterior extremity

of the one succeeding, and so on throughout the chain. These joints are farther strengthened by capsular ligaments, and besides this, the oblique or articulating processes of each vertebra are locked to those of the next by ligaments; and thus, while almost unlimited freedom is allowed, the security of the joints is amply provided for. The spinous processes of the vertebræ are short; and these, with the mode in which the oblique processes are united, tend, in some degree, to limit the backward flexure of the spine, especially in the rattlesnake, in which the spinous processes are more developed than in most other species. The slender tree-snakes, however, can twine their bodies in any direction. The ribs of snakes are attached to the transverse processes of the vertebræ, which latter offer a convex, articulating surface, fitting into a concavity at the head of the rib. This articulation permits the ribs to play backward and forward very freely, and they are under the agency of five distinct sets of muscles, disposed in regular layers, the contractions of which operate in bringing them forward, or drawing them backward. In these active and often dangerous reptiles,

the ribs assist in locomotion; they take the place of limbs, and their action is very like that of the limbs of the millepede, as may be ascertained by any person who will allow a snake to crawl quietly over his hand, when their action will be plainly felt. It is, in fact, on the ends of the arched ribs, that the snake rests, and each pair is connected by means of a slender cartilage, and a set of short muscles, with one of the scuta or broad abdominal scales, with which the under surface is invested. As the ribs are put into action, each pair, on being advanced, carries forward with it the scale to which their extremities are attached; then the next scale in succession, and again the next, are brought forward in progressive order, the anterior ribs retaining the advantage gained, by the energy of the muscles which govern them. These scales may therefore be regarded each as a common foot to a pair of ribs, and their posterior edges, which overlap each other, aiding the ribs in their progressive advancement, by catching hold of the ground or other objects, become in turn so many fixed points, whence the forward movement is dated.

It is well known, that the terrible boa

crushes its prey to death by encircling it in its folds; grasping any fixed part or object with its tail, it is by means of this peculiar action of the ribs, the creeping of which beneath the skin may be perceived, that it tightens its compression, till the very bones of the victim give way. Thus it is, also, that, when a powerful snake is held in the grasp, the creeping of the ribs may be distinctly felt; and with such power do they work, that not without great difficulty can the reptile be prevented from gliding through the hand; for every step it takes it improves upon, and even the firmness of the grasp, unless so tight as to prevent the muscles from acting, seems rather to assist its efforts.

With respect to the saurian reptiles, we find, as might be expected, various modifications in the spine, and the parts immediately connected with it, as we proceed through this multitudinous order of reptiles, from the crocodile to the blindworm. As a general rule, it may be observed, that the vertebræ are numerous, principally owing to the length of the tail. In most species, the cervical vertebræ are seven or eight in number; but the

dorsal vertebræ, or those bearing the true ribs, differ in number in the various species: the ribs are attached to the transverse processes, and join the sternum by cartilaginous elongations; although some of the anterior ribs, and also of the posterior ribs, more particularly, have their extremity free and unattached, at least in many instances.

In the crocodiles, the sternum, which is broad and osseous anteriorly, is continued beyond the limits of the chest, as a slender cartilage along the centre of the abdomen to its lowest margin; and this cartilaginous continuation gives off on each side eight slender cartilaginous ribs, pointing obliquely backwards, and terminating in the muscles of the abdomen, which they support. These sterno-abdominal ribs are not connected with the spine, their extremities are free.

There is a peculiarity in the neck of the crocodile which may not be passed by; we allude to additional pieces to the transverse processes of the cervical vertebræ; these pieces overlap each other, and greatly impede the lateral flexure of the neck, so that the animal cannot turn suddenly and rapidly round, or bend the neck sideways to make a snap. This

rigidity of the neck is strongly contrasted with the flexibility of the powerful tail of this terrible reptile, the lateral movements of which are extremely free. With this powerful instrument the crocodile lashes the water to foam, and deals the most tremendous blows, striking from side to side with astonishing violence. If we examine the vertebræ of this part, we shall find them furnished not only with superior but with inferior spinous processes of great length for the attachment of powerful muscles, which render it a most efficient weapon, as well as oar or paddle. Nevertheless, though at all times formidable, it is in the water that the crocodile revels in his might; if he seize his prey on the bank, instantly he rushes with it into the river, and there disappears in an instant. On the land, its limbs are ill adapted for rapid movements; its neck, as we have said, is rigid, and its upper surface is protected by solid pieces of mail, or osseous plates, with bold ridges, disposed in longitudinal rows; hence, therefore, flexibility of the body is at a low par, and the power of turning suddenly considerably restricted. The crocodile must, in fact, make a circuit in order to reverse its

course; and, therefore, unless it dart unawares on its prey, may be avoided without much difficulty. Far otherwise, however, is it in its congenial element; there its powers are all displayed to advantage, and woe to the animal swimming in the river, on which it darts with fierce impetuosity.

If we turn to the skeleton of the chameleon, with its clinging limbs and prehensile tail, we find another modification of structure, equally harmonious. In the short neck of this reptile, the vertebræ are reduced to five in number; and the spinous processes of the dorsal vertebræ are very large and broad, forming in the living animal an acute, elevated ridge down the middle of the back; while the ribs inclose a voluminous chest for the ample lungs, which in this animal are singularly developed.

We may well contrast the skeleton of the chameleon with that of the frog, one of the amphibia, which is remarkable for its simplicity, and the total absence of true ribs. While in a tadpole state, the skeleton of this well-known little creature is thoroughly fish-like, the vertebræ having cup-like cavities filled with elastic gelatine, which, being inter-

posed between the bodies of each, allows of considerable facility of motion. The tadpole, as we know, is furnished with a tail or caudal paddle, by the action of which it propels itself in the water; through this tail the vertebræ are also continued. But a singular and very surprising change soon takes place, not only in the organs of respiration, (which are at first gills,) but in the totality of the osseous framework. First, the hind-limbs begin to bud forth, and when these have assumed something like a definite shape, though still very small, the anterior limbs begin to germinate, and gradually assume their due form and proportions. While this is going on, a change is taking place in the spine: the tail is gradually absorbed, the process of absorption commencing at the tip, and proceeding gradually to the base, till the whole disappears. The spine is at the same time losing its fish-like mode of articulation. The ball of elastic gelatine, which interposed between each of the vertebræ, filling the cup-like cavities of the two in juxtaposition, and giving them liberty of motion, or rather a sort of spring-like action, becomes converted into cartilage; and this cartilage

becomes united to the end of the vertebra in advance of it, continuing to play in the cup of the next succeeding. Subsequently, this cartilaginous ball becomes ossified, and part and parcel of the vertebra to which it was attached. Thus a true ball-and-socket joint is formed—the projecting ball or convexity at the end of one vertebra playing in the concavity at the anterior portion of the next vertebra in succession.

This description refers to the ten true vertebræ of which the spine of the frog consists; but below these, and united to them at an angle which produces an abrupt point in the back of the frog, as if the spine were broken, runs a single slender bone, originally divided, being, in fact, a consolidation of a few of the most basal tail-bones of the tadpole, and those immediately anterior to its base: this bone is called the *os coccygis*, and on each side of it, but removed from it, run the slender haunch-bones. The breast-bone in the frog, though partially cartilaginous, gives origin to the abdominal muscles, and is considerably developed; the shoulder-bones consist of the clavicle, the coracoid bone, and the scapula, or blade-bone; and

to the articulating cavity of the latter the head of the arm-bone is fitted, and farther secured by a round ligament, (*ligamentum teres*,) similar to that which binds the head of the thigh-bone to its socket in most quadrupeds. This security of the shoulder-joint in a reptile, which proceeds on land by a series of vigorous leaps, is doubtless requisite, in order that it may bear unrestrained, or without dislocation, the shock to which it is liable, when the animal comes down on its fore-limbs, after making its spring. The hind-limbs are very long and muscular, and are the chief organs of progression, both in the land and in the water.

The changes which take place in the osseous system of the frog—and we here say nothing of the respiratory and circulating system, from its tadpole to its mature state—are indeed very wonderful; they are, moreover, within the observation of all who are curious to examine for themselves, and watch the stages of life from immaturity to perfection.

In the young, or tadpoles of the water-newt, (*Triton*,) so abundant in clear ditches and ponds, similar transformations take place to those in the tadpole of the frog, with these

exceptions, that the anterior limbs are the first to bud forth, and the tail is not absorbed, but remains persistent, and is the sole organ of aquatic locomotion, the hinder limbs never acquiring the development which they do in the frog. On land, the newt crawls slowly along, but is extremely active and vigorous in the water.

Here, then, we are presented with creatures which begin life with the skeleton and the respiratory organs of fishes, but which gradually lose the characters of the latter animals; they acquire lungs, and their skeleton, at the same time, undergoes a wonderful alteration, from the growth of parts not originally possessed, and the great modification of others. These examples of formative and transmutive power, so clearly indicative of the omnipotence of the great Creator, cannot but appeal to us as proofs of design in the laws of organic structure. He that investigates them, and denies the existence of God, or affirms that God is not manifest in the structure and changes of organic beings, must wilfully blind his understanding, and harden his heart against conviction. Nor can we think more highly of the man, who, in his investigations of nature, is content with the acquisition of facts, and, while

believing in the God of heaven and earth, never rises from the creature to the Creator with feelings of awe and adoration.

Wonderful as is the transformation of an animal in a fish-like condition to a different grade of existence, still more so is the fact that some of the amphibia never lose the characteristics of fish, and yet, at the same time, acquire lungs adapted for atmospheric respiration. They are really amphibious, and though, as a rule, they live in water, still some inhabit swamps, and occasionally visit the dry land, in quest of worms and insects.

Among these remarkable creatures is the proteus, a dweller in the subterraneous waters of the cavern at Adelsburg, where no ray of daylight ever penetrates; the axolote of the lake of Mexico, and the siren of the morasses and swamps of Carolina. These animals have free branchial fringes, or gills, and also delicate lungs. Their skeleton is very simple, and their movements in the water are similar to those of fishes; the proteus, indeed, much resembles a slender eel; the limbs being so small, that, at a first glance, they may be readily overlooked.*

* For an account of these amphibia, see Popular History of Reptiles: Religious Tract Society.

CHAPTER VIII.

THE VERTEBRAL COLUMN OF FISHES.

From these creatures—partly reptiles, partly fishes—we come to the class of vertebrate animals to which the term fishes is with propriety restricted. We have already given a general sketch of the leading characteristics of this class, and, in tracing the modifications of the anterior extremities, we were led to a consideration of the pectoral, and also the ventral fins of these aquatic creatures; and, although we abstained from minutiæ, we ventured to show some of the most remarkable modifications to which these analogues of the limbs of the higher animals are subject. We described the pectoral and ventral fins as combining with the tail to fit these scaly tenants of the waters for easy motion in their native element; and we have now to show how the spine harmonizes with the structure

of those fin-limbs, and indeed with every other part of their organization, being, in fact, what it ought to be in animals so expressly formed for the medium they tenant, and the part assigned them in creation.

Let us take one of the fishes with a truly osseous skeleton, say the perch, and investigate the details of the spine. From the head to the caudal fin, a column of vertebral bones is carried nearly in a straight line, or in a line more or less arched; and to these bones and their mode of articulation, the vigorous actions and the flexibility of the tail are owing. In the mammalia, the vertebræ are divided into cervical, dorsal, lumbar, and so on; but in fishes, no such division is admissible. Fishes have no true neck, and no chest; they breathe by means of gills on each side of the head at its junction with the body, and are consequently destitute of those voluminous lungs, which, with the heart, are contained in the chest of quadrupeds. Yet, there is a division in the vertebræ of fishes, for the more anterior are furnished with ribs,* varying in development; in the perch they are rather slender,

* In some fishes, the ribs are mere rudiments, and in others, as the skate, they are wanting.

but are large and strong in the carp; to these rib-bearing vertebræ the name of abdominal has been given, while the rest are termed caudal. The bodies of the vertebræ are short, and consequently the spine is made up of numerous pieces, a circumstance which, conjoined with their mode of articulation, contributes to its elasticity. If we look at a detached vertebra, we shall find that at each end it is hollowed out into a sort of cup-like cavity, or a conical depression. In their natural situation, the edges of these cups are united by a very elastic ligament, and the hollow part, or double cone, (formed by the two cups joined rim to rim,) is filled up with a highly elastic glutinous substance, which allows not so much a free play of one vertebra on another, as a general mobility; the extent of motion possessed by a single vertebra is multiplied in the whole series forming the spine, the elastic mobility of which, thus obtained, is very considerable. When the vertebræ cease to be put into motion, or bent by the action of the muscles, the column resumes its linear direction, the ligaments that unite the edges of the cups, rendering it straight by an involuntary contraction. It is evident, therefore, that the

vertebral column cannot be bent at an abrupt angle, and whoever will watch the actions of a fish in the water will see, that whatever degree of flexure the caudal portion may display, the curve is regular and graceful.

It is only laterally in such fishes as the perch, carp, salmon, and others, that the flexure of the spine occurs; the muscles being so arranged as to act accordingly. Yet it may be observed, that the processes of the vertebræ, the bodies and union of which we have described, forbid flexure in any other direction; thus the vertebræ, and the muscles that govern them, are in just harmony. Each vertebra gives off a large upper spinous process, arising from a double origin, so as to form an arch at its base. The multiplication of these arches forms a canal for the lodgment of the spinal cord, which is thus protected as it runs along the spine. Similar processes, called the inferior spinous processes, proceed from the under part of the bodies of the caudal vertebræ, and through the canal at their base the aorta is transmitted in its passage along the spine.

The number of the vertebræ varies considerably in different fishes. In some we count only from thirty to forty; but the spine of the

shark is composed of upwards of two hundred.

When we speak of the ribs of fishes, it must not be supposed that they subserve the same purpose as the ribs in quadrupeds or birds; they are imbedded in the muscles of the sides, to which they give attachment, and, in many fishes, are furnished with numerous slender appendages, buried also among the muscular fibres. In the herring, these are very abundant. We shall not here notice the interspinous bones running down the ridge of the back, nor those forming the fin-rays, which are either hard and spinous, as in the perch, or soft and cartilaginous, (with the exception, sometimes, of the first dorsal and pectoral rays,) as in the salmon, trout, carp, etc. These bones must be regarded as appendages, which are infinitely varied, and which do not necessarily enter into the composition of the spinal column even as adjuncts.

We have described the structure of the vertebral column as we find it in the osseous fishes—fishes in which the skeleton is the most completely ossified—and altogether the most elaborate. There is, however, an extensive group of fishes in which the skeleton is never ossified, but remains permanently in a state of

cartilage, generally tough and firm, but sometimes extremely delicate; and, in these fishes, we find a considerable modification of the vertebræ composing the spinal column. As examples of this group, we may mention the shark, the sturgeon, the skate, the ray, the lamprey, the myxine, and the lancelet.

In the shark and sturgeon, the bodies of the vertebræ are circular in form; and, in many cases, there is a central communication between one cup, or double conical cavity, and another, throughout the whole length of the spine. In the skate, remarkable for the enormous development of the pectoral fins, the bones of the shoulder, in a cartilaginous state, are attached to two large lateral processes at the upper part of the spine, while the cartilaginous framework that supports the ventral fins is simple and unconnected with the vertebral column. The anterior portion of the spine in this fish is not divided into distinct pieces, while, in the posterior part, "the number of vertebral arches is twice as great as that of the separate bodies of the vertebræ." In the lamprey, the bodies of the vertebræ are annular, and perforated in the centre; hence a continuous canal, filled with gelatine, runs through the spinal column.

In the myxine, the vertebral column is reduced to a soft, flexible, cartilaginous tube, very indistinctly divided into separate pieces, and filled with a gelatinous fluid. The spinal cord appears in the form of two slender filaments, which run parallel to each other in a groove at the upper part of the tubular column, and are protected only by a delicate membrane. In the lancelet, the lowest in organization among fishes, destitute of scales, and perfectly transparent, the spine, its only internal support, is merely a slender, flexible, cartilaginous stylet, running the whole length of the body; and from this cartilage numerous muscles diverge. This curious and very rare fish is scarcely an inch and a half in length. It has been taken on the Cornish coast, but we believe the only one now in England is that in the possession of Mr. Yarrell. "This specimen," says that naturalist, "the only one I ever saw, and which is probably the only one that has been taken for many years, was sent to me by Mr. Couch, who found it himself on the shore near Polperro. A portion of the tail of this little fish was sticking out from underneath a stone in a small pool left by the tide. Mr. Couch perceiving it, took it up with some water

in the hollow of his hands. It was alive, very active, and so transparent that the viscera were perceivable through the external covering." The celebrated Pallas possessed a specimen of this strange fish, also taken, singular to say, upon the Cornish coast; and according to Mr. Yarrell, he is the only writer who had previously noticed the species. Pallas regarded it as a slug, and not a fish, and termed it *Limax lanceolatus.* It has neither eyes, gill-covers, scales, nor fins, except one along the ridge of the back. The mouth is on the under part of a narrow elongated head; and is fringed on each side with a row of slender filaments. We agree, however, with Mr. Yarrell, that the lancelet comes within the pale of the fishes, between which and the mollusca it may be regarded as a connecting link.

We have seen among quadrupeds and reptiles, the tail converted into an instrument of prehension; among quadrupeds, the spider-monkeys and opossums are examples in point, and the chameleons among reptiles. Among fishes, the hippocam us has the long taper finless tail prehensile, like that of the chameleon.

Mr. Yarrell, in his valuable work on British

Fishes, describes and figures the short-nosed hippocampus, which, though rare, has been taken on the Hampshire coast, in Swansea Bay, and at Guernsey, and the other channel islands. "At the time of writing," says Mr. Yarrell, June 9, 1835, "Mr. Lukis (of Guernsey) had two female specimens of *Hippocampus brevirostris*, then healthy and active, which had been living twelve days in a glass vessel; their actions equally novel and amusing. 'An appearance of search for a resting place induced me (says Mr. Lukis) to consult their wishes by placing sea-weed and straws in the vessel; the desired effect was obtained, and has afforded me much to reflect upon in their habits. They now exhibit many of their peculiarities, and few subjects of the deep have displayed, in prison, more sport or more intelligence. When swimming about, they maintain a vertical position, but the tail is ready to grasp whatever it meets in the water, and quickly entwines in any direction round the weeds, and, when fixed, the animal instantly watches the surrounding objects, and darts at its prey with great dexterity. When they approach each other, they often twist their tails together, and struggle

to separate or attach themselves to the weeds; this is done by the under part of their cheeks or chin, which is also used for raising the body when a new spot is wanted for the tail to entwine afresh. Their eyes move independently of each other, as in the chameleon; this, with the brilliant changeable irridescence about the head, and its blue bands, forcibly remind the observer of that animal.' "

Thus, then, in the prehensile tail of this fish, have we an organ of touch and an instrument for grasping; a substitute, to a certain degree, for the hand, and used by the animal for moving itself while it looks out for prey. We may easily conceive that the vertebræ of the flexible elongated tail are modified so as to admit of the necessary freedom of motion—and that the arrangement of the muscles must be very different from what it is in the ordinary examples of the present class. In connexion with this departure from the ordinary type of structure, the habits and manners of the hippocampus are peculiar. It swims in a vertical position, and very easily and gracefully, by means of an undulating movement of the tail, aided by the pectoral and dorsal fins; it clings to objects for support, and has been observed

to take repose curled up in oyster-shells. With the modification of the tail, the anterior part of the body undergoes a decided alteration, and is modelled into a rather slender and arched neck, so that the head, instead of being in a line with the body, forms an angle with it—the snout projecting horizontally forward. The contour and mutual position of the head and body offer, as Cuvier says, a resemblance in miniature to the head, neck, and chest of the horse, and hence the name of hippocampus, or sea-horse,* which, with a classical allusion, he applied to this genus. Thus, then, in every class of vertebrated animals, excepting birds, we are presented with examples in which the extreme portion of the vertebral column is modified as a grasping organ, and either acts by way of aiding the hands or paws, or becomes a substitute for those organs, surprising us by its strong power of prehension, and its endowments as an organ of touch.

So far, then, have we pointed out the leading and characteristic modifications of the vertebral

* Hippocampus, from ἵππος (*hippos*,) a horse—καμπη (*campé*,) a flexure. This name was given by the ancients to imaginary sea-horses, figured as drawing the chariot of Neptune. The anterior parts were those of a horse; the hinder parts were fish-like, and wreathed in folds or flexures.

column, in quadrupeds, in birds, in reptiles, and fishes, glancing at the parts of framework more immediately connected with it. We have shown how it harmonizes with the limbs, and the prescribed method of locomotion in various groups of animals; we have traced it from its maximum of development to its almost obliteration in the lowest fishes; and we have contrasted it among the subjects of each distinct class, our endeavour being throughout, to bring forward plain and obvious proofs of wisdom and power in creation. To the spinal column we were naturally led from a general review of the structure of the anterior limbs, between which and the spine there must be a correspondence of harmony. A flexible spine, and rigid columnar legs, or a rigid spine, like that of the tortoise, and light elastic limbs, like those of the leopard, would be a palpable violation of the rules of organic harmony. The vertebral column of the snake forbids the possibility of wings like those of the bat or bird; while the vertebral column of the bird, in conjunction with the rest of its framework, shows that for these organs it is expressly modelled. And here we may observe that with the organic modifications of animals, with their

diversities of structure, their instincts precisely correspond; nor does instinct ever urge to any act or the performance of any operation for which organs are not expressly provided. Is an animal urged by instinct to chase its prey through the air, then it will have wings: the anterior limbs, the spine, and the whole framework, will be modified accordingly. Is an animal taught by instinct to live underground and there procure its food, then it will be provided with scrapers, and every part, even to its fur and the development of the eyes, will accord to fit it for its destined mode of life. Is an animal led by instinct to hang to the branches of trees and there gather its leafy diet, then will it be provided with the means—look at the arboreal sloth. Are races destined for aquatic existence, expressly for such a life will be their organization,—among mammalia, the whale; among birds, the penguin; among reptiles, the marine tortoises may be cited; while one great class, that of the fishes, is *par excellence* aquatic.

It has been said that animals are induced by their organization to certain modes of life, that their structure influences their instinct—but this we cannot agree with. It is very true that

instinct and structure accord, and necessarily go together; but we cannot say that structure determines instinct, for, if so, then the animal, by repeated trials, must discover its peculiarities of organization, and from experience deduce the best and most advantageous mode of operation. But, so far is this from being the case, that the young of any species, as soon as it has strength, displays the instincts and modes of its progenitors. A duckling just hatched will immediately make for the pond, and set itself fearlessly afloat, paddling with its webbed feet, as if it had been previously familiar with the water. The young crocodile, or alligator, immediately on exclusion from the egg, buried in the warm sand, crawls to the river; and, when interrupted, has been known to assume a threatening attitude, and snap furiously at the stick presented to it. The young bat, as soon as it is capable of shifting for itself, launches boldly into the air, and flits in many a mazy course, pursuing the insects which come forth in the dusk of evening.

We might prove our position by hundreds of cases in point, but it is needless; it is by the guidance of instinct, that animals apply their organs, promptly, decidedly, without hesitation,

or consideration, in the very manner in which they were intended to be applied. They act, not because they reflect that they are structurally fitted for this or that plan of operation, but because instinct impels them, and instinct never impels to any action which the animal has not the means of accomplishing. No animal hesitates in what manner to attack its prey, or in what manner to avoid its pursuer. No animal hesitates as to the mode of life it shall lead, or the labours it shall perform. No animal emulates the habits of another, unless it is, in like manner, organized for them. This organization for definite modes of life, of acquiring food, of avoiding enemies, is palpable in the structure of the limbs and spine; the modifications of which are as varied as are the instincts and habits of the numerous tribes of earth, air, and water; nor are these modifications limited to those parts—they are carried out, more or less strongly, through all the details of the animal body, every part, so to speak, being dove-tailed into unison with the rest.

When we speak of the instincts of animals in accordance with their structure, we naturally revert to man, and the question suggests itself,

Is he under the same law? Partly so, and especially during his long and helpless state of infancy. Instinct leads the child to the mother's breast; and even in mature years, we instinctively raise our arm to avert a blow or threatened danger. But let it be remembered, that mind, reason, reflection, memory, imagination, begin early to develop themselves in man, and he is specially organized for the guidance of mind, in contradistinction to instinct. His hands are not diggers, like those of the mole, but he can make the plough and the spade; he cannot gnaw down trees like the beaver, but he can make the saw and the hatchet, and, what is more, he can improve upon his first beginnings, and advance step by step in the arts of life, till his rude hut becomes the palace of the Cæsars, and his wicker coracle a floating city on the waters. He has no natural instruments, but, one being made, it enables him to make others; and these, others again; and so on in accumulating ratio, till at last he surrounds himself with the most complicated machinery, and, instead of contenting himself with a mere provision for his necessities, aims at the possession of luxury and splendour. Hence he unlocks the doors

of commerce; he ransacks the earth for the valued productions of different climes, and, what no other animal does, he invents a system of exchange, the dawn of which we see even in the earliest history of his career on the earth.

Nor must we stop here: unlike other animals, man cultivates the arts and sciences. He has learned how to transfer the scenes of nature or the human form divine to the canvas, or to carve the marble into exquisite grace. To him are given languages in contradistinction to sounds. It is his to feel the beauties of poetry, and to record the history of passing events; he looks back upon the past, and looks forward to the future; he has dared to investigate the structure and properties of organic bodies—to analyze inorganic matter, and resolve it into its elementary particles, and, soaring still higher, he has measured the distances and revolutions of the planets, and demonstrated the path of the globe on which he treads.

Does not man, then, considered in this light, apart from revelation, appear to be a most wonderful and extraordinary being? Does he not seem destined for something more than an

existence of threescore years and ten? Has he not a consciousness of his great pre-eminence? Stands he not isolated and, as it were, on a pedestal above the animal creation around him, among them but not of them, with high aspirations, with longings after immortality? And is there this solecism in the laws of creation, that he is really no more than other animals, except in degree, all ending with his present existence? If so, he is a still more extraordinary being, and we shall in vain endeavour to discover the motive of his creation—the final cause of his existence. But no, the reason that is given us is sufficient to prove to us, from a consideration of man as an animal, as a rational animal, not only higher than the brutes, but opposite to them, that this life is not our only term of being. Why else have we conscience?—why ideas of a great and wise God, derived from a study of his works?—why a dream that such a state as a future existence is even possible?—whence, too, arose the erroneous belief of idol gods, and of future rewards and punishments, or even of retributive justice in this life? How came men to adore anything, and why such a feeling as that of adoration, however erroneous in its

object? Because man is immortal, and accountable for the deeds done in the body. He may err, he may, in ignorance, worship an idol, or gods with attributes of his own imagination, personifications of virtues or vices, or of the elements around him, but the substratum remains still, and only bears an unworthy superstructure. That substratum is a knowledge of immortality and accountability, taught to primeval man, and never destroyed, though often obscured and defaced; nor can the atheist divest himself of the sense of this truth, under which he leads a miserable existence, relieved only when he ceases to reflect upon it.

Such are our deductions, looking as naturalists only at man, and considering him apart from revelation. What shall we say, then, when revelation comes in to confirm a truth deduced from other sources—and not only so, but offers a sure and plain guide, a light unto our steps, that we may avoid the track of error, till we enter a heavenly kingdom, where all darkness shall be for ever dispelled?

And here the naturalist may end—he has offered proofs of the power, wisdom, and goodness of our Lord Jesus Christ, for by him were all things created—and pursuing

his argument, has shown the position which man occupies in the animal world, a position perfectly unique, but no less in harmony with his physical than his mental constitution. In this point of view, the distance between the rudest savage and the highest brute, is immeasurable.

But the Christian contemplates man under another aspect—he considers him as he is represented in the revelation which the Almighty has condescended to make, and which depicts him as fallen from a state of rectitude, and amenable to the curses of a broken law, and to the justice of an offended Lawgiver. Did it stop here, it would leave man no hope, it would afford him no gleam of consolation; but it proceeds still farther—it teaches him how justice and mercy can meet, and points out the way to life eternal.

While on the one hand it humbles man, by showing him the degradation of his moral nature, and by unveiling the secrets of his own heart—by condemning him even in his own judgment, and by opening before him the consequences of his transgression; it also points to the great Atonement, offered for the sins of the world, and calls him to lay

hold of the promise of pardon and everlasting life, by faith in that Mediator who bore our sins in his own body on the tree, and who, though sinless, became a sacrifice for sin, that the doors of mercy may be opened, while the justice of God is satisfied.

Some writer has well said, that "The Christian religion is the highest style of man;" or, in other words, that man is ennobled and dignified by that faith which elevates him above the things of time and sense, and leads him to place his chief affections on heavenly and incorruptible treasures—upon the glories of that kingdom which is the believer's inheritance. Surely, then, if the philosopher is permitted to argue from the position of man in the animal creation, that his destiny is as different from that of lower creatures, as he himself, in all his qualities and endowments, differs from them, the Christian, standing upon a still firmer rock of evidence, and filled with the "assurance of faith," may advance a step farther, and invite attention to the great scheme of salvation, in which are seen in glorious display, the wisdom, and mercy, and justice of the God of nature and the

God of grace. In this scheme, as revealed by inspiration, we learn what mere philosophy cannot teach—we see man as philosophy cannot delineate him—and we behold the position in which he stands with regard to God, his final judge.

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